Intrinsic k_T from "target" jet recoil: Detector Requirements

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Thanks to: J.H.Lee, J. Lajoie, J. Huang, R. Seidl

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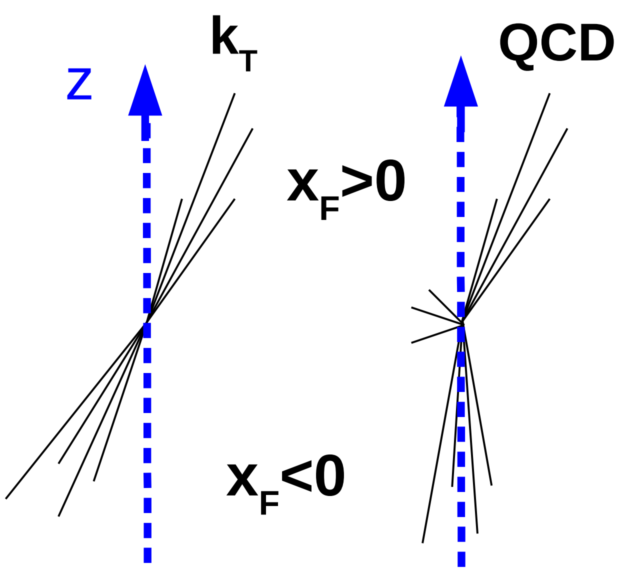
Reminder: intrinsic k_T

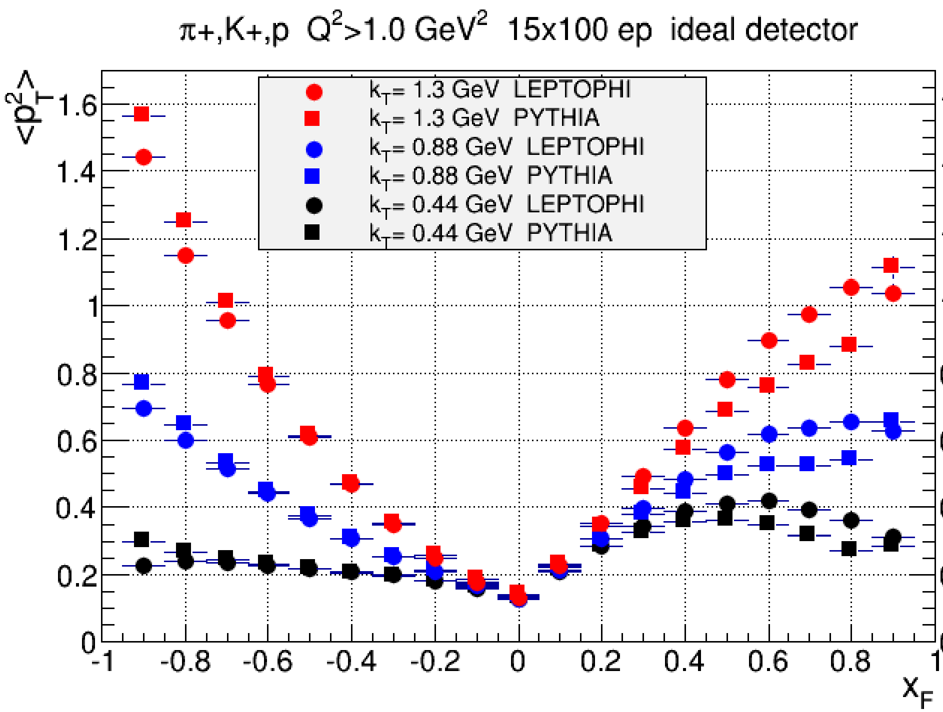
Basic physics points:

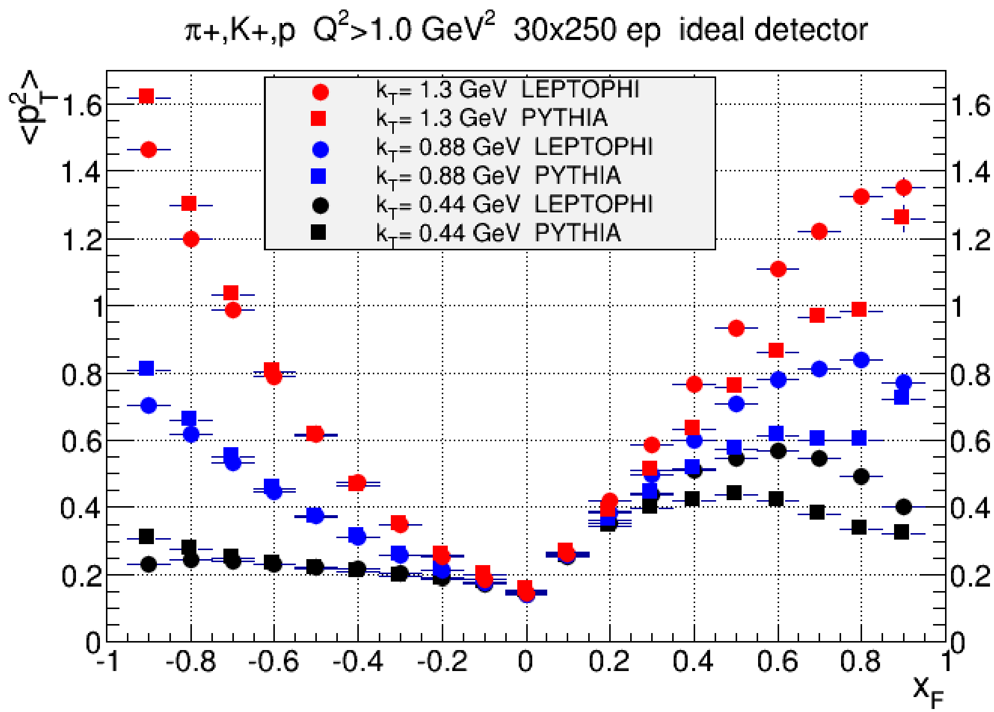
1. Target remnant k_T = - struck parton k_T
2. QCD radiation mostly at x_F~0
3. QCD also gives a p_T kick to the struck parton x_F>0



- Primordial parton k_T shows up in both hemispheres.
- QCD radiation only shows up at $x_F \geq 0$

Reminder: Seagull plots and k_T

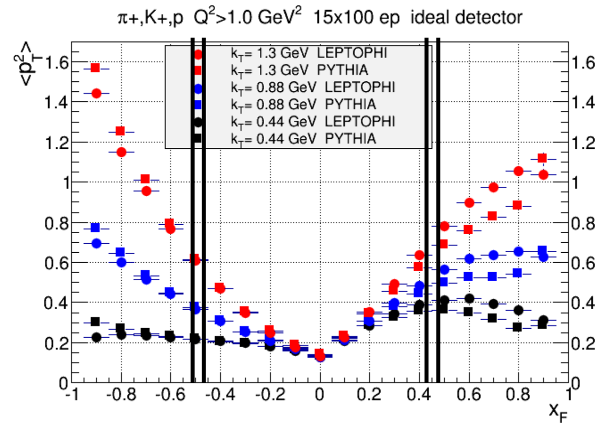




Intrinsic k_T shows up most cleanly in the region $-0.8<x_F<-0.3$

$x_F>0$ affected by QCD: increased energy & model dependence

With spectra, still want negative x_F

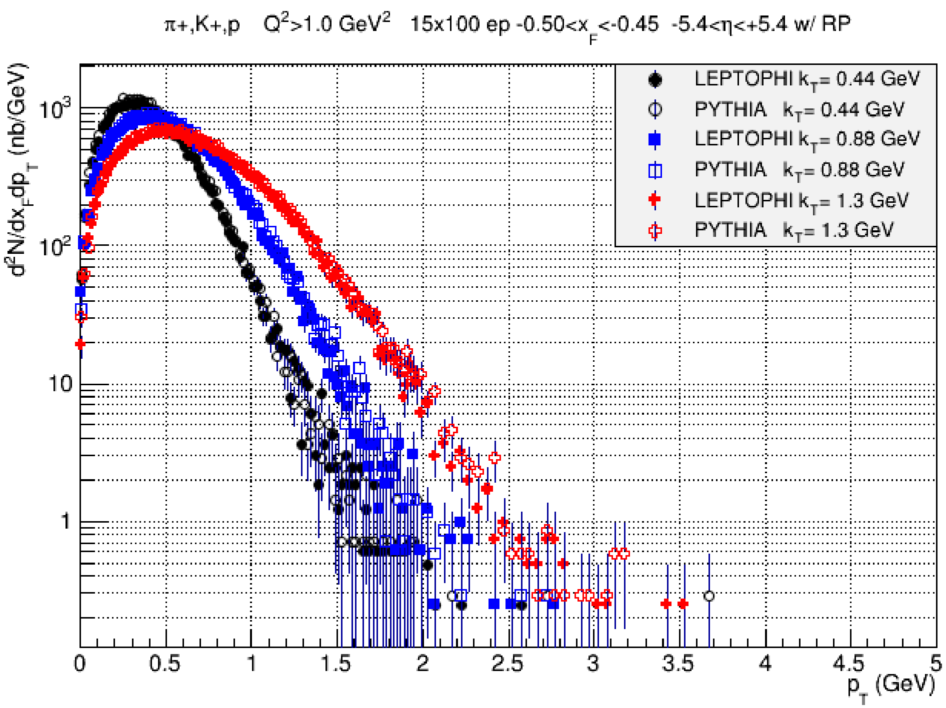


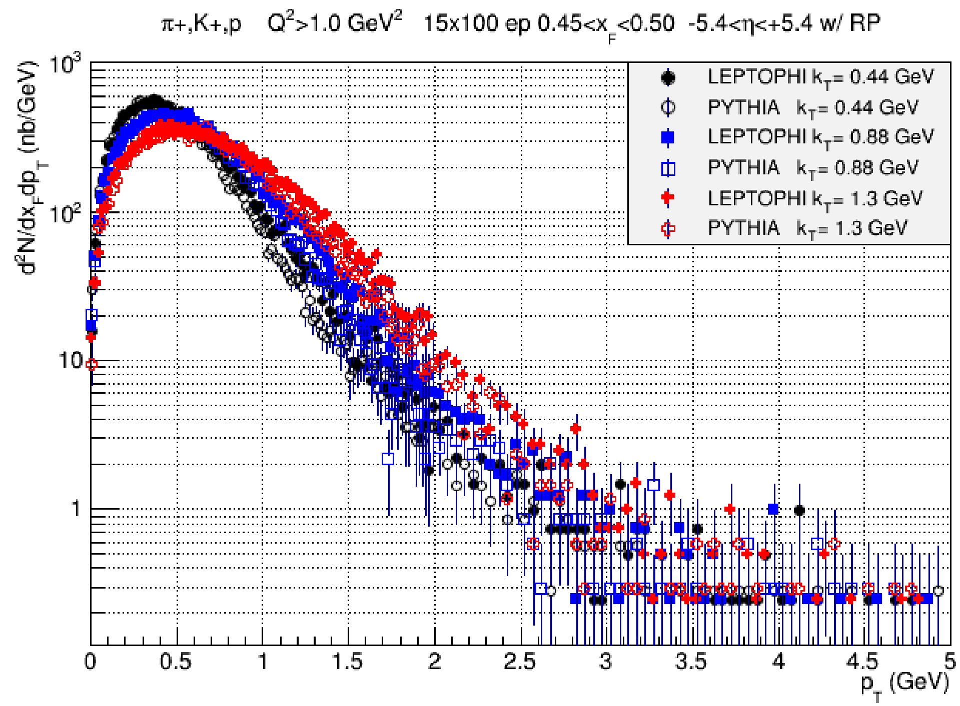
LEPTOPHI & PYTHIA

$-0.5<x_F<-0.45$

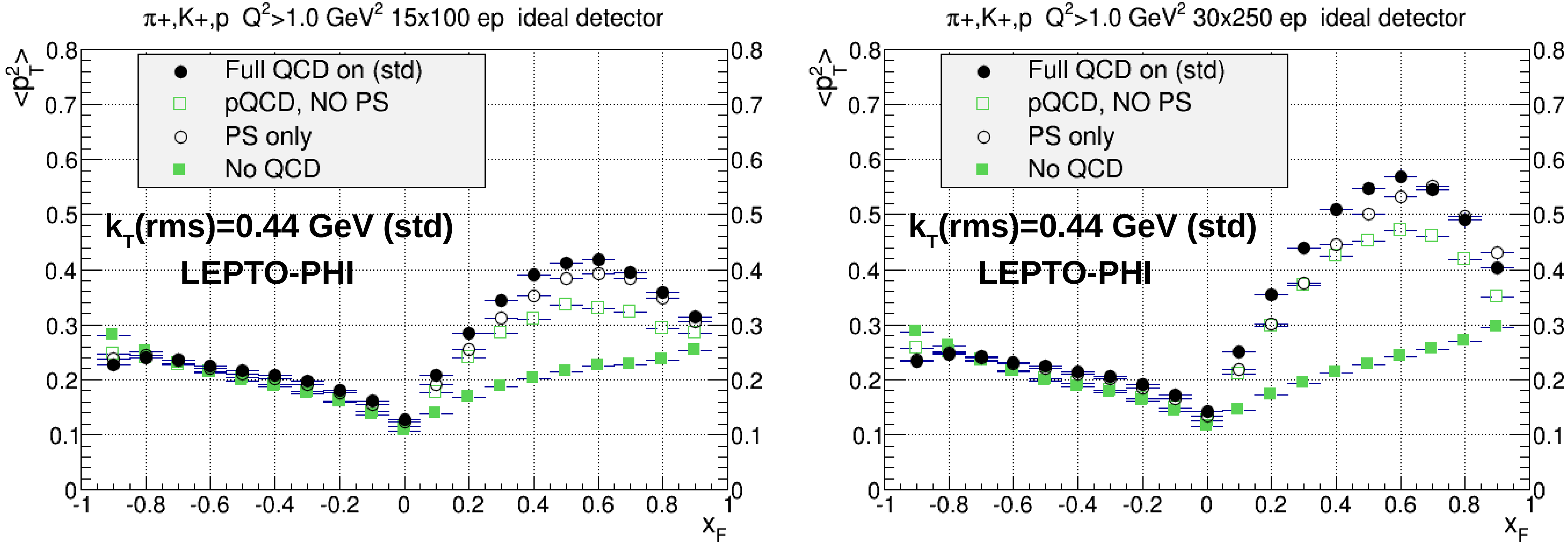
LEPTOPHI & PYTHIA

$+0.45<x_F<+0.5$





Reminder: QCD & Intrinsic k_T



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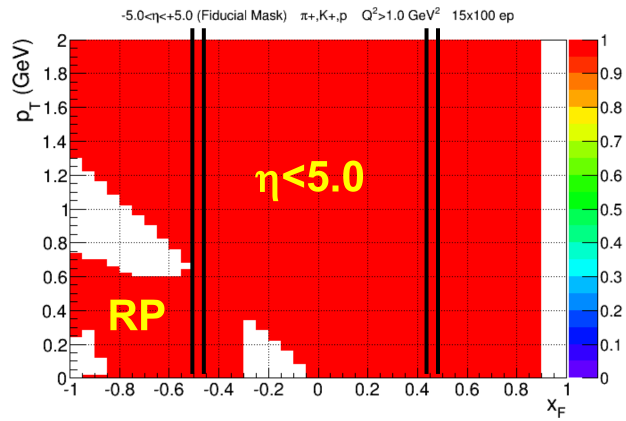
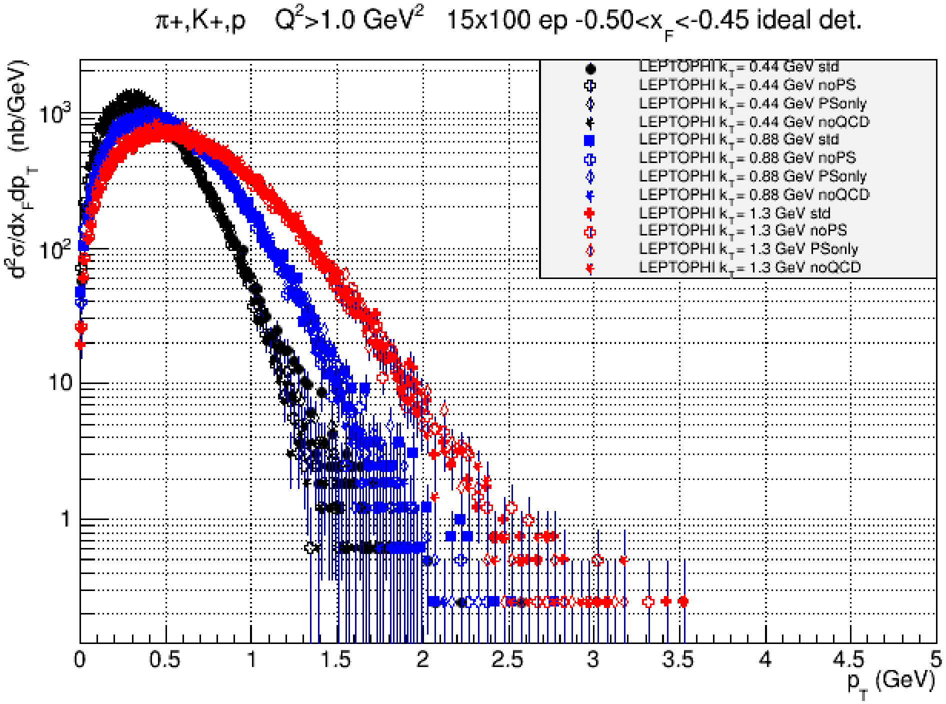


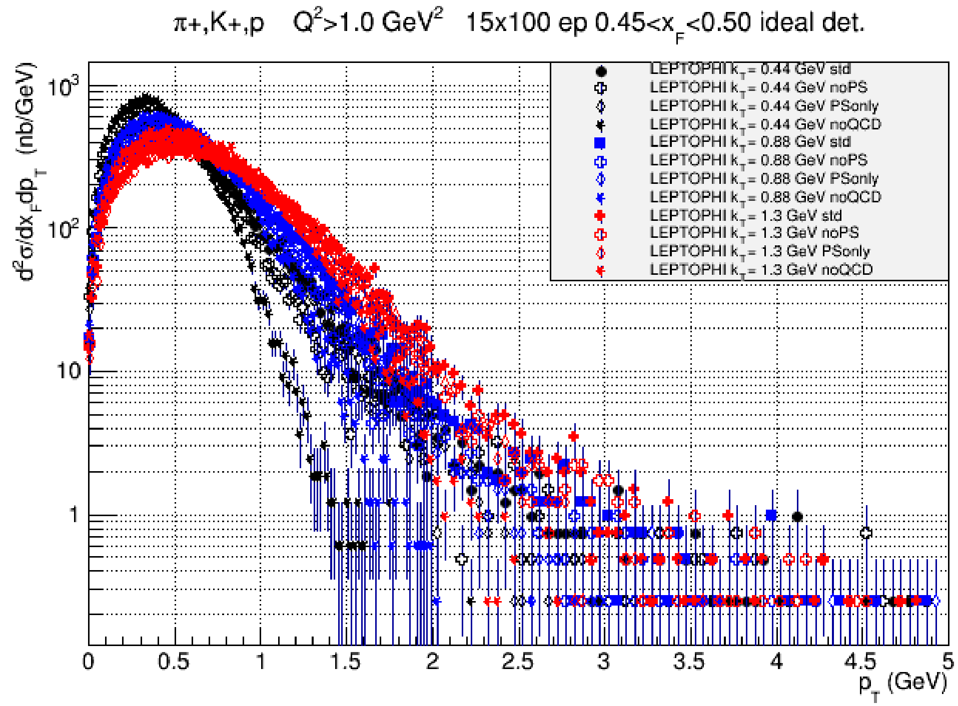
LEPTOPHI QCD on/off

$-0.5<x_F<-0.45$

LEPTOPHI QCD on/off

$+0.45<x_F<+0.5$





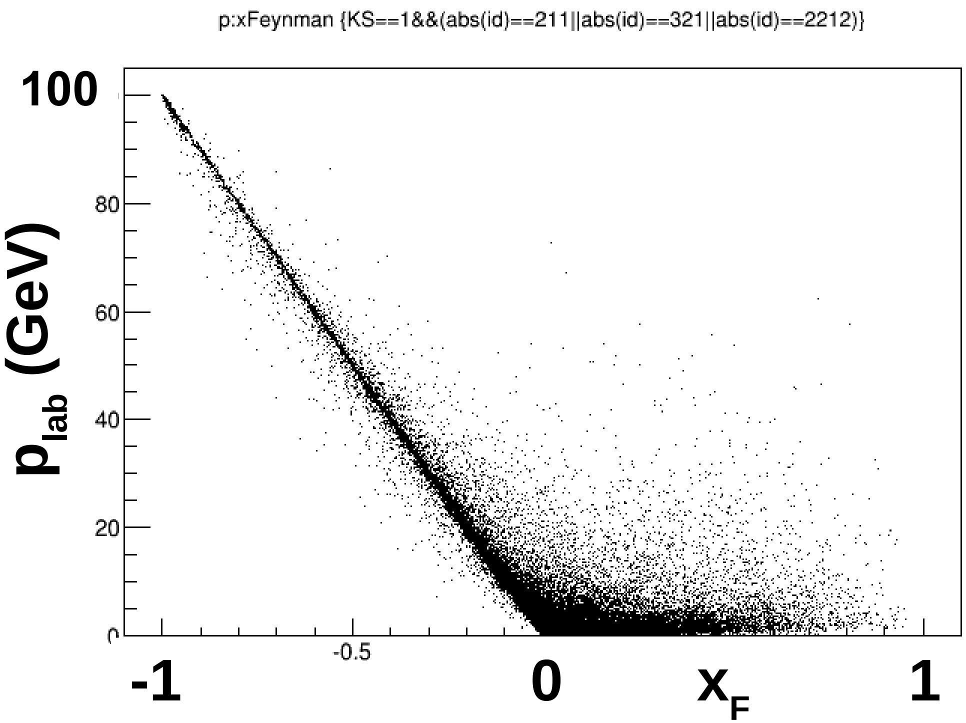
Map lab acceptance to HCMS

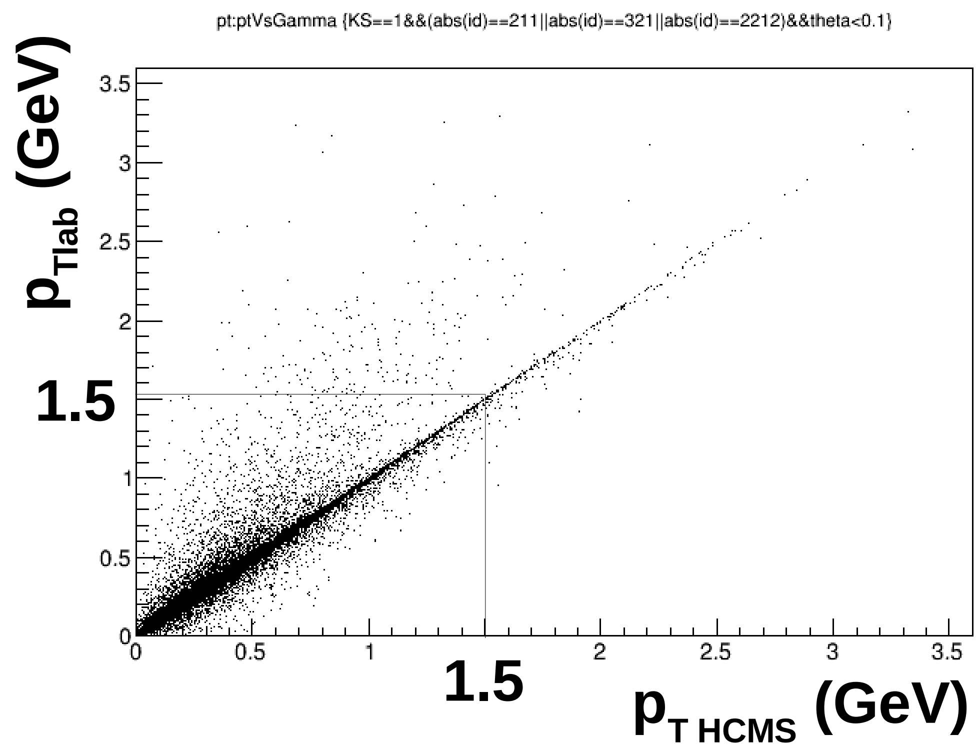
EMPIRICALLY ($Q^2 > 1\ \mathrm{GeV}^2$):

$x_F \approx -p_{hlab}/p_{beam(p)}$

& for small θ_{lab} (relative to p):

$p_T \approx p_{Tlab}$ (for $\theta < 100$mr)



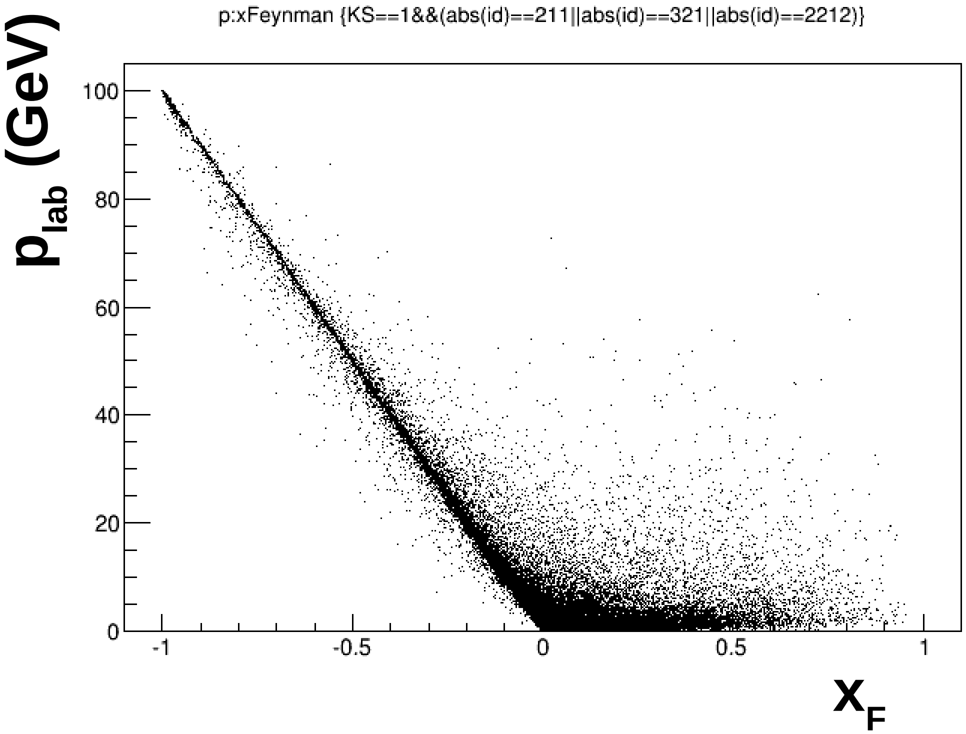


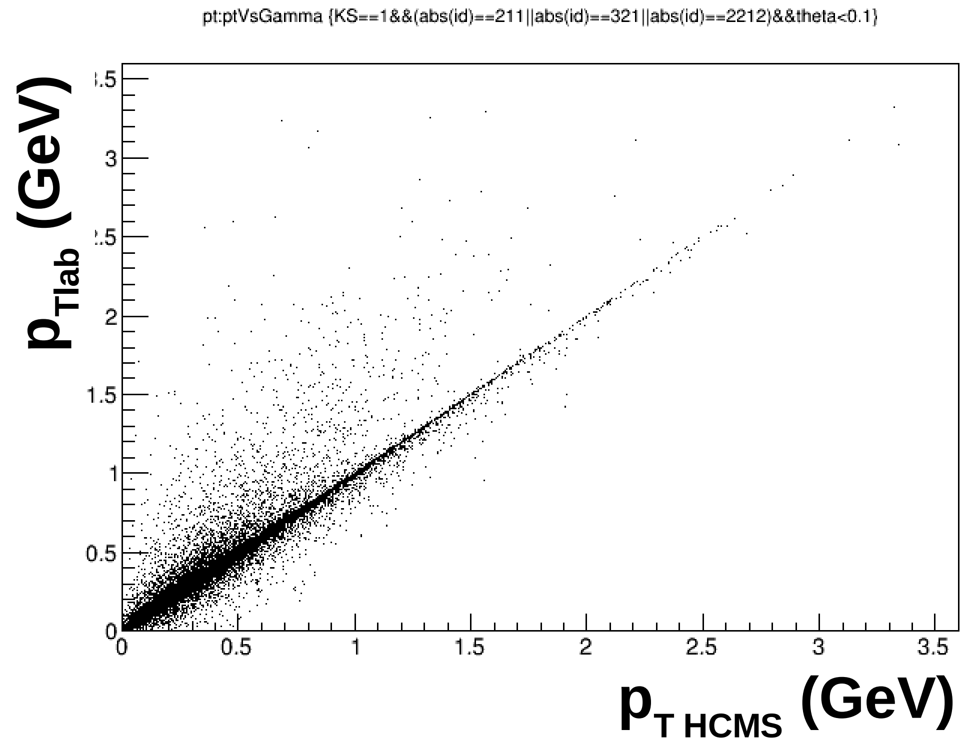
WHY? Because $q_{z\text{-lab}} \sim 0$, so lab → HCMS boost along z

Key detector requirement!

Large negative x_F means very large p_{lab}

To get a reasonable $p_{T\text{-}HCMS} \sim p_{Tlab}$ then requires small θ.





The rest is details!

Map lab acceptance to HCMS

So, For fixed small θ_{lab} (relative to p):

$x_F \approx -p_{hlab}/p_{beam(p)}$

$p_T \approx p_{Tlab} \sim p_{hlab} * \theta_{lab}$ IMPLIES $p_T \approx -(2e^{-\eta lab} p_{beam(p)})\, x_F$

$p_{beam(p)} = 100\text{GeV}$, $\eta_{lab} = +5.1$:

$p_T \approx -1.22\text{ GeV} * x_F$

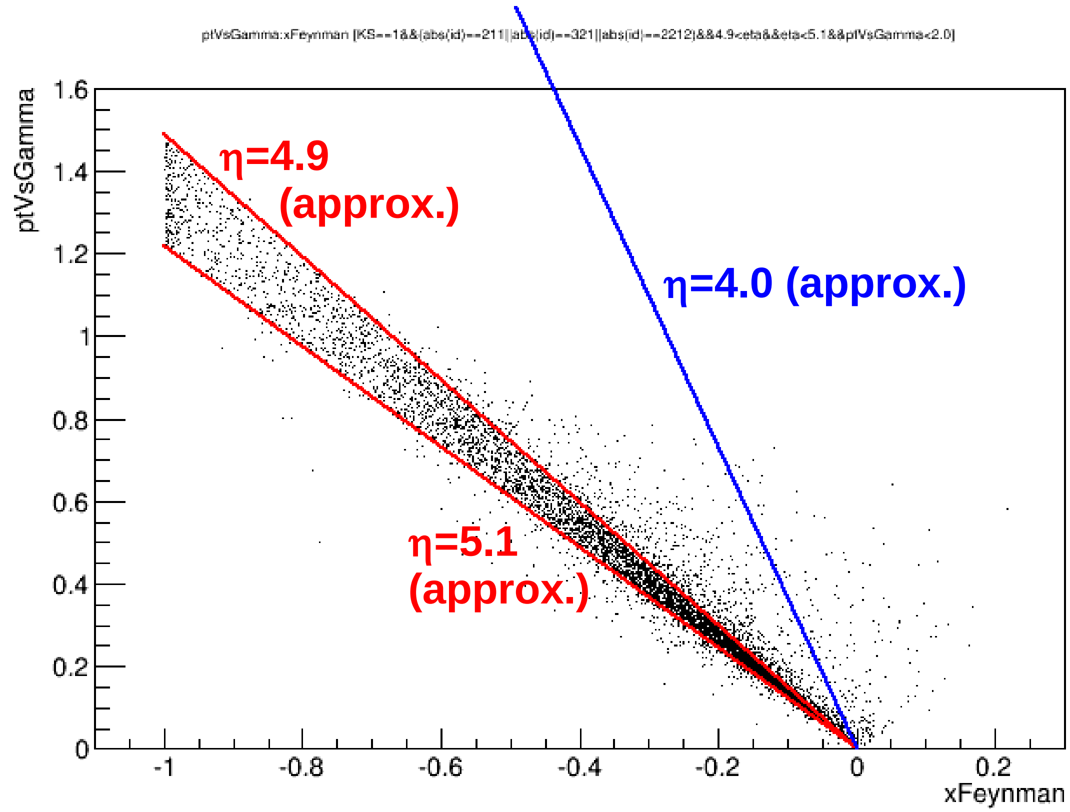
Map lab acceptance to HCMS

So, For fixed small θ_{lab} :

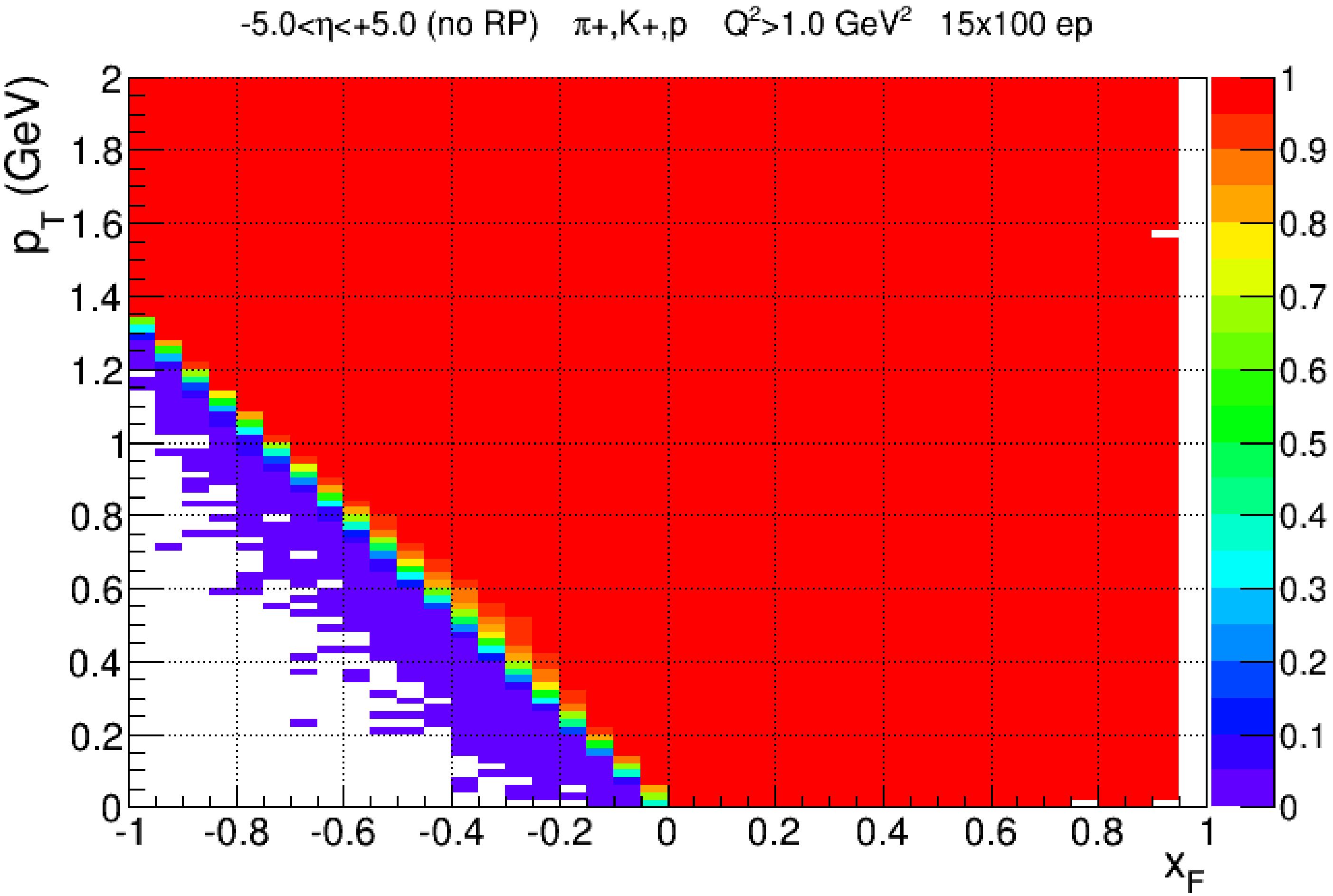
$p_{beam(p)}$=100GeV, η_{lab}=+5.1:

$p_T \sim -1.22$ GeV * x_F

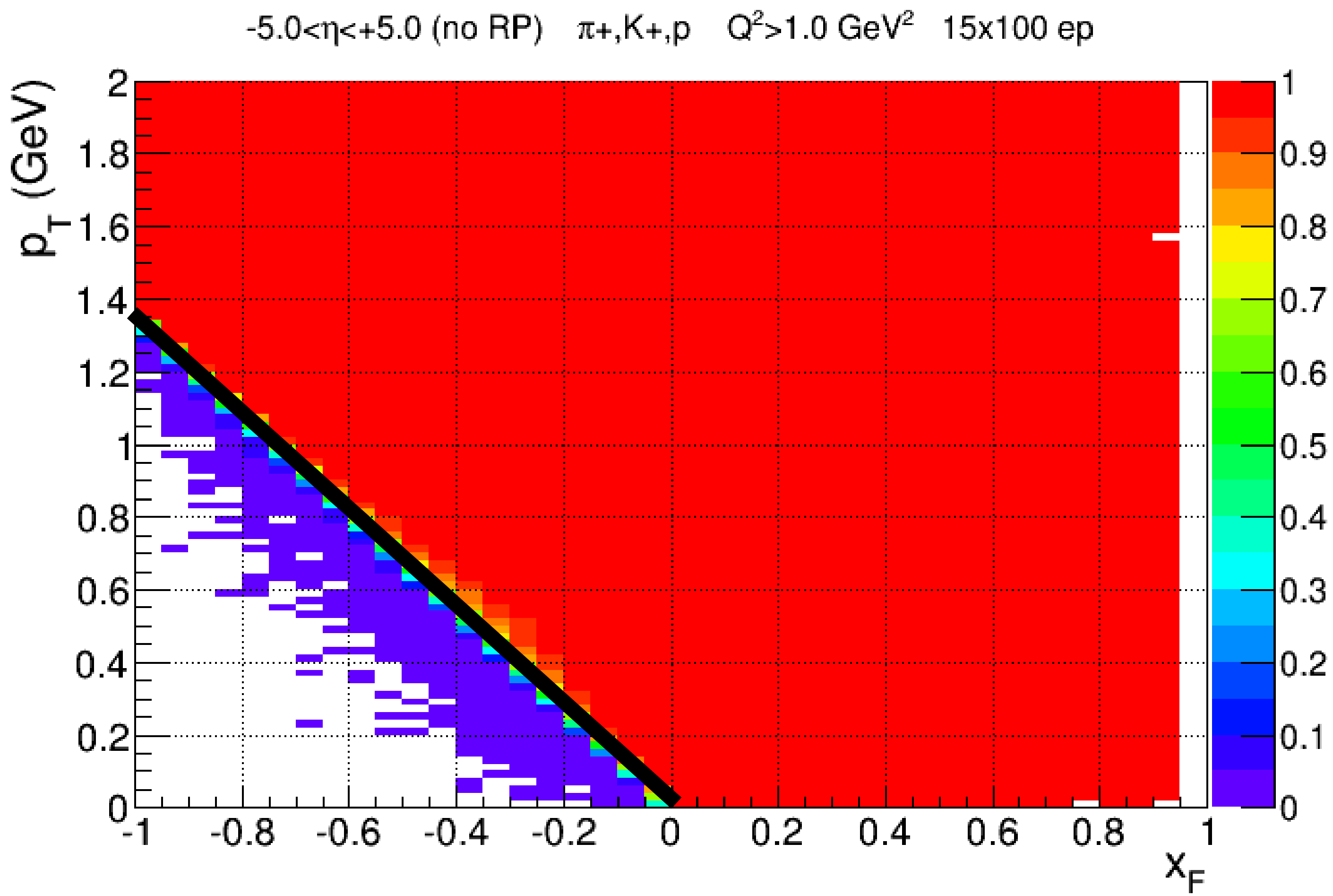
Scatterplot for 4.9<η<5.1
15x100 GeV ep, Q^2>1GeV^2,
with approximate η edges



Acceptance using MC (LEPTOPHI)



How good is our approximation?

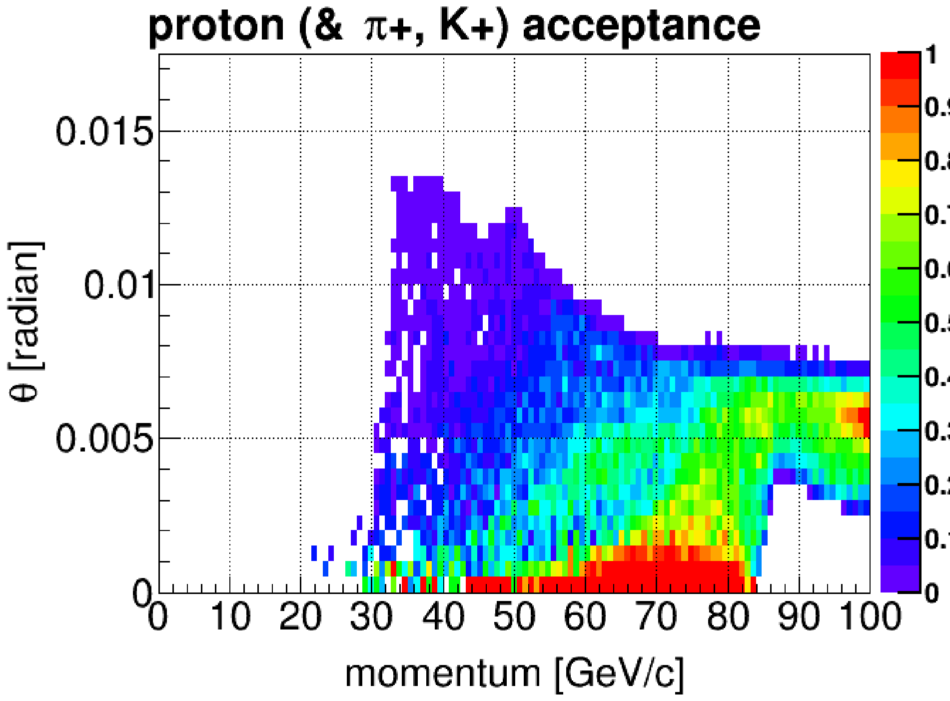


$p_{beam(p)}$=100GeV, η_{lab}=+5: $p_T \sim -1.348\ x_F$ (GeV)

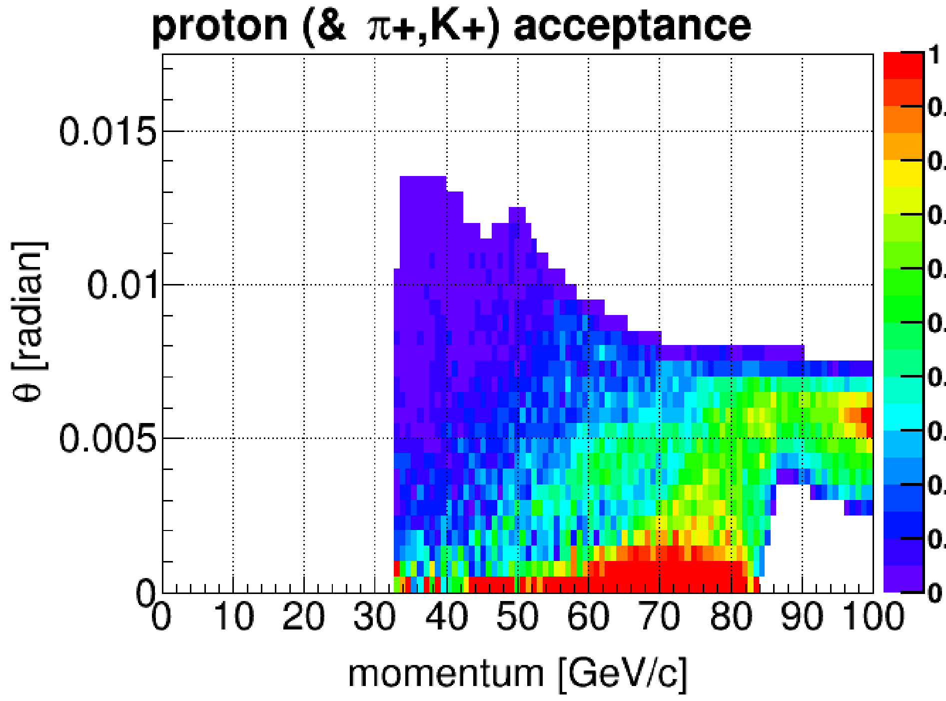
Roman Pot Azimuthal Acceptance

For 100 GeV proton beam

From J.H. Lee

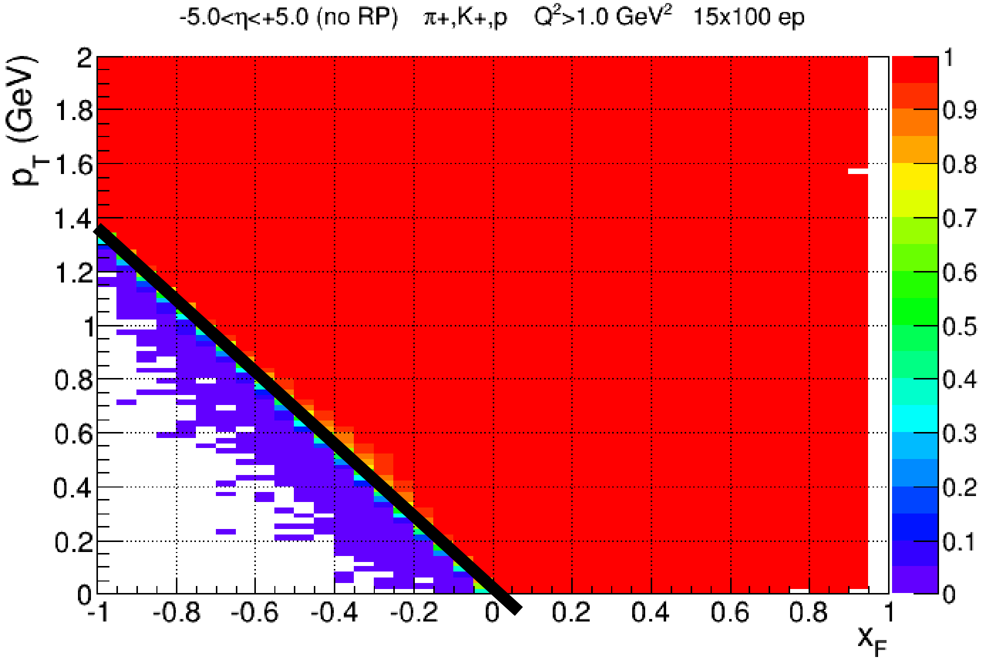


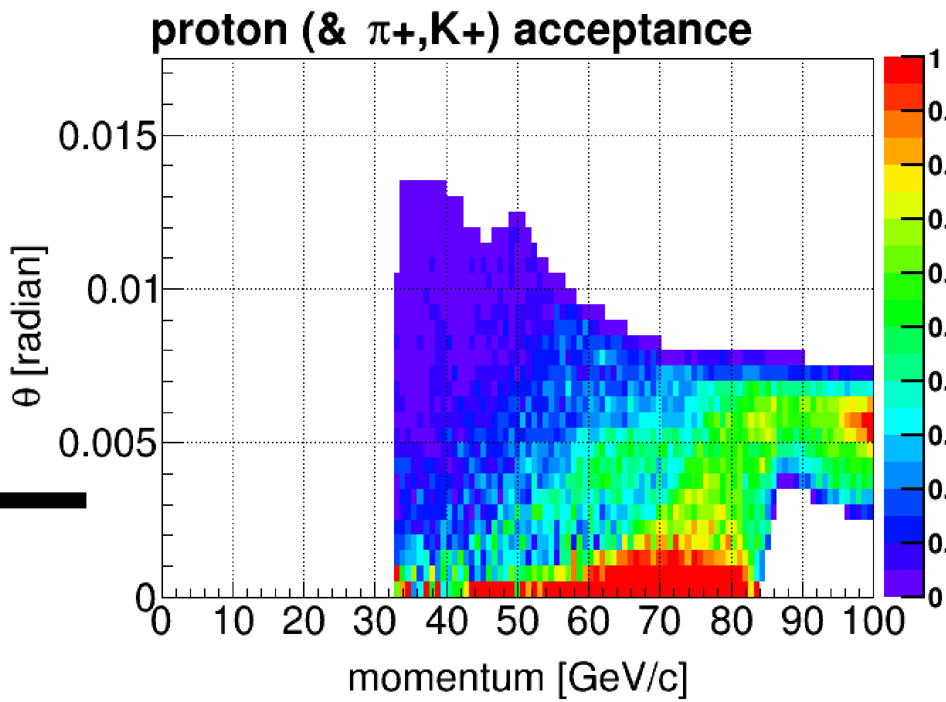
Interpolate 0/0 values
& make cleaner edges

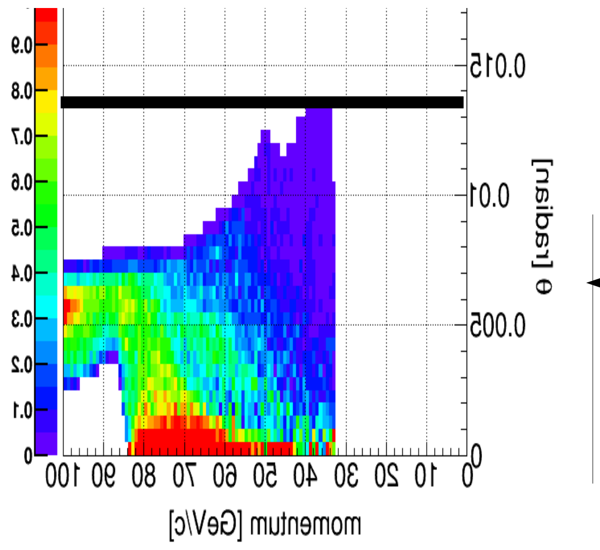


Roman Pot acceptance is ~100% in a specific region of p,θ,ϕ
i.e. most of the fractional acceptance <1 refers to a an azimuthal cut

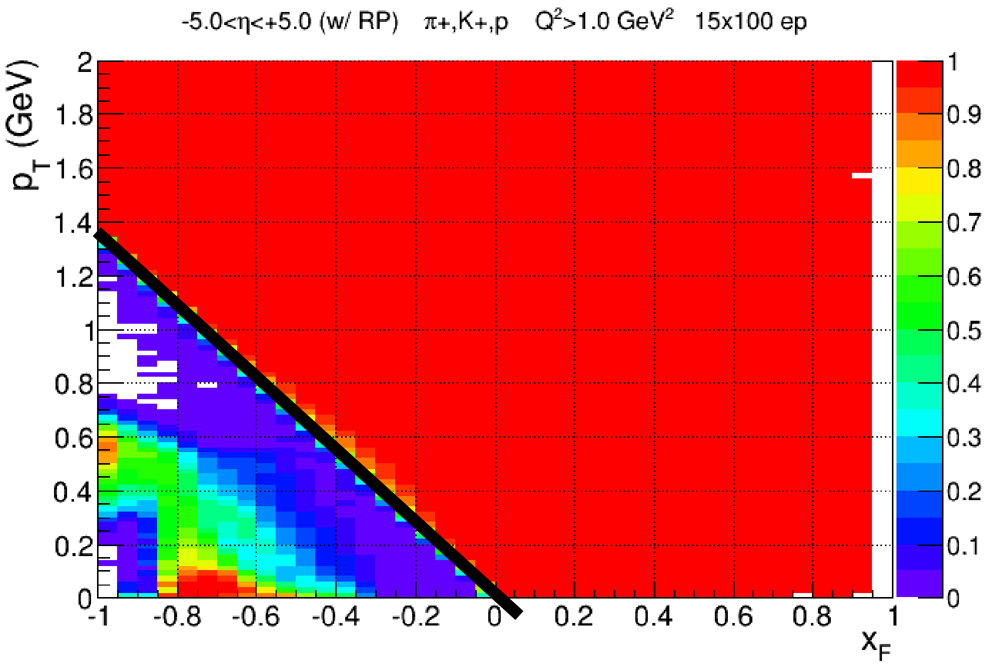
Roman Pots in HCMS

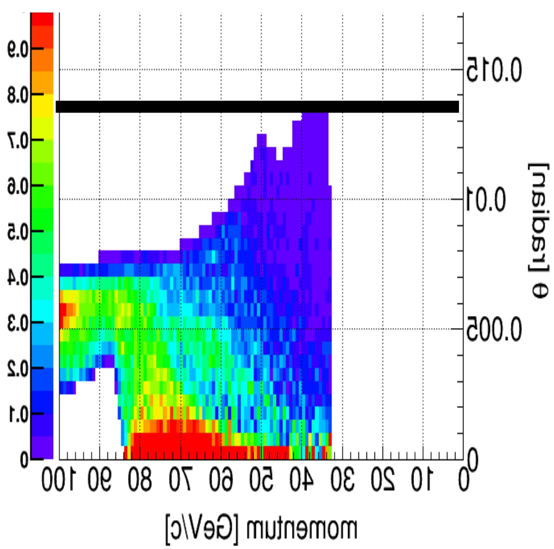






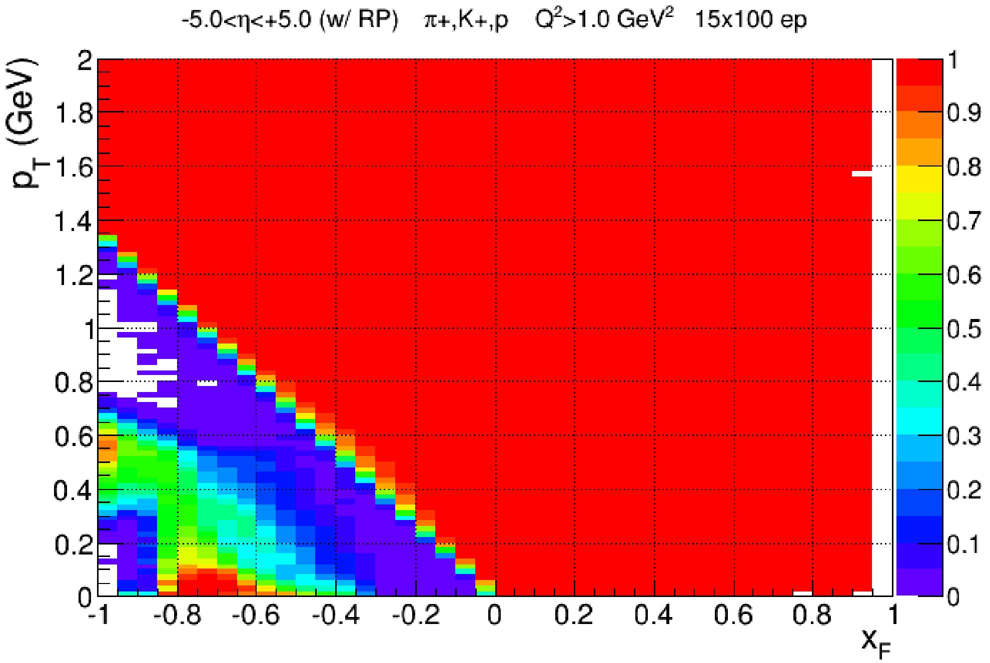
HCMS acceptance with Roman Pots



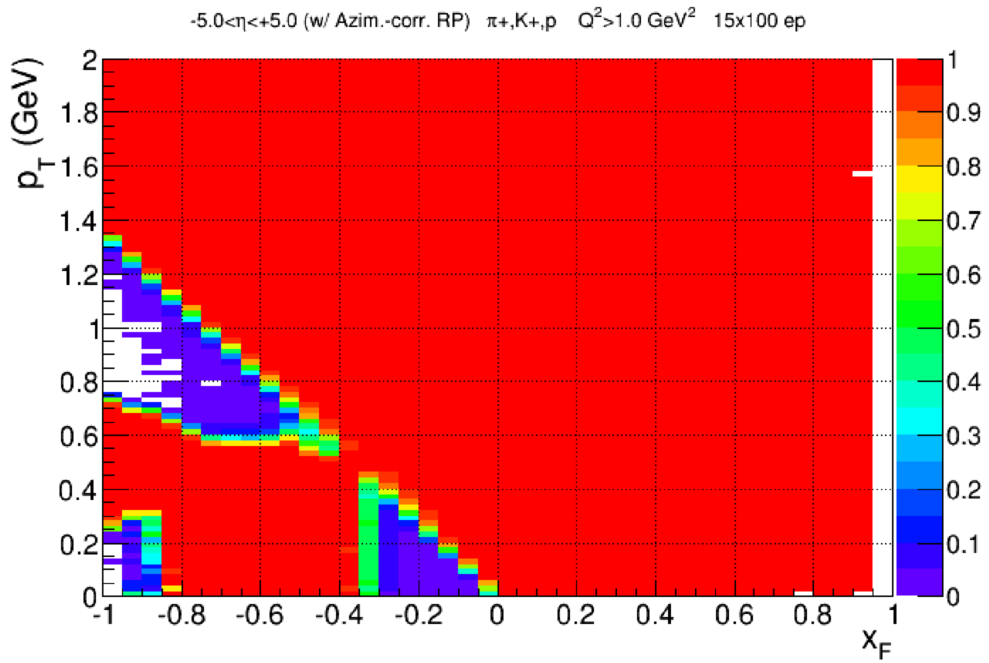


What region is "Measurable"

Acceptance



Azimuthally Corrected Acceptance

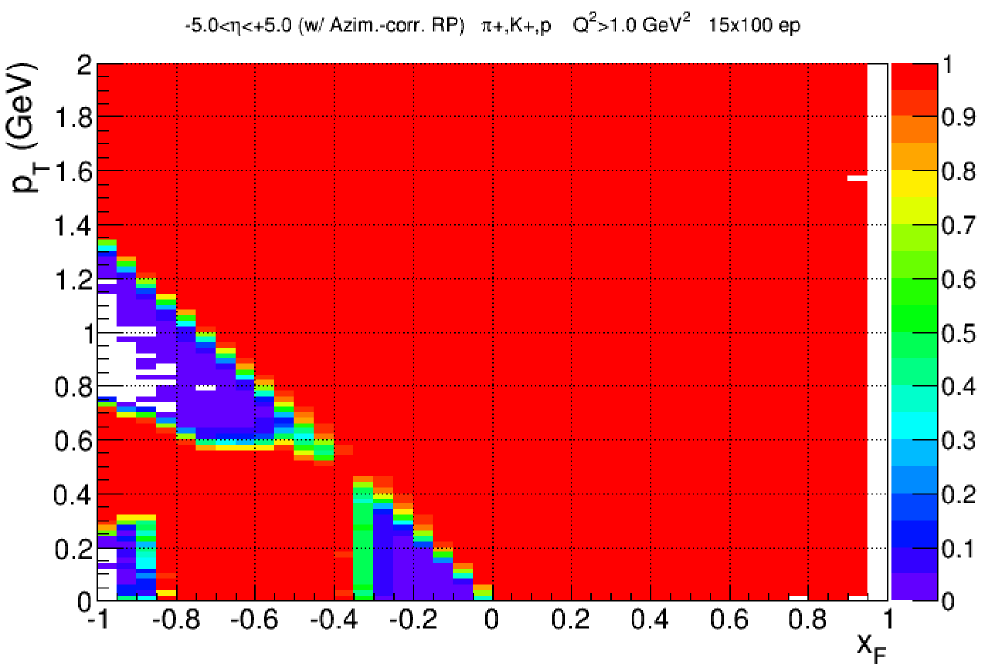


Step 1:
Map lab acceptance to x_F, p_T

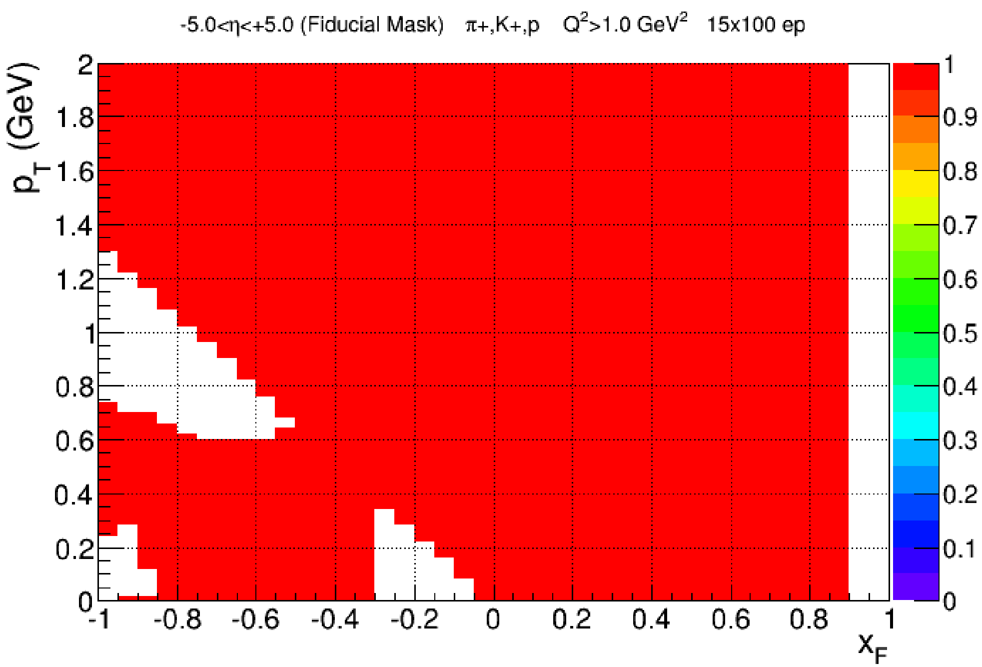
Step 2:
Azimuthally correct Roman Pots for regions with >40mr acceptance

What region is “Measurable”

Azimuthally Corrected Acceptance



Measurable region (fiducial)



Step 2:
Azimuthally correct Roman Pots for regions with >40mr acceptance

Step 3:
Require at least 25% Az.Cor.Acc. (and x_F<0.9)

5 Schematic Detectors

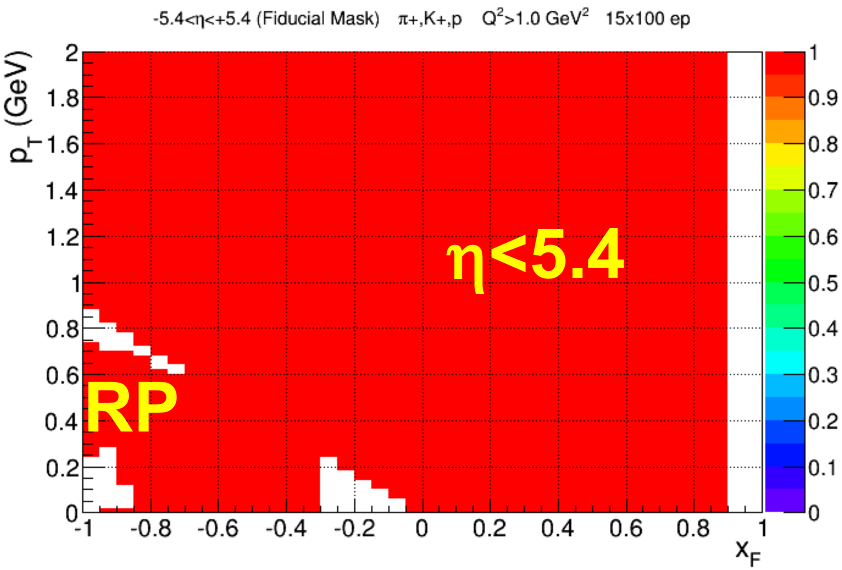
- $|\eta|<5.4$ + RP
- $|\eta|<5.0$ + RP
  - To match RP, we need at least charge selection to augment HCAL out to η of 5.
- $|\eta|<4.5$ + RP
- $|\eta|<4.0$ + RP
- $|\eta|<5.0$ + NO RP

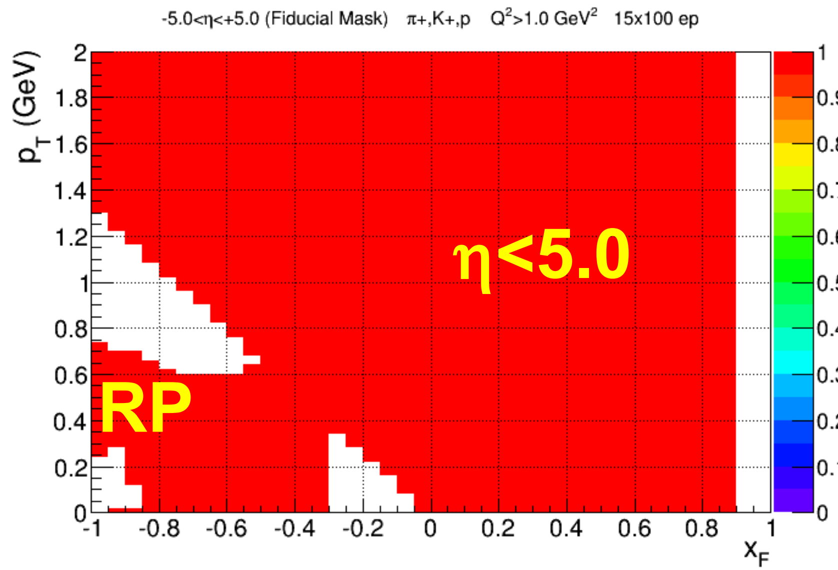
NOTE: $-3 < |\eta| < +5$ is equivalent to $-5 < |\eta| < +5$ for our purposes

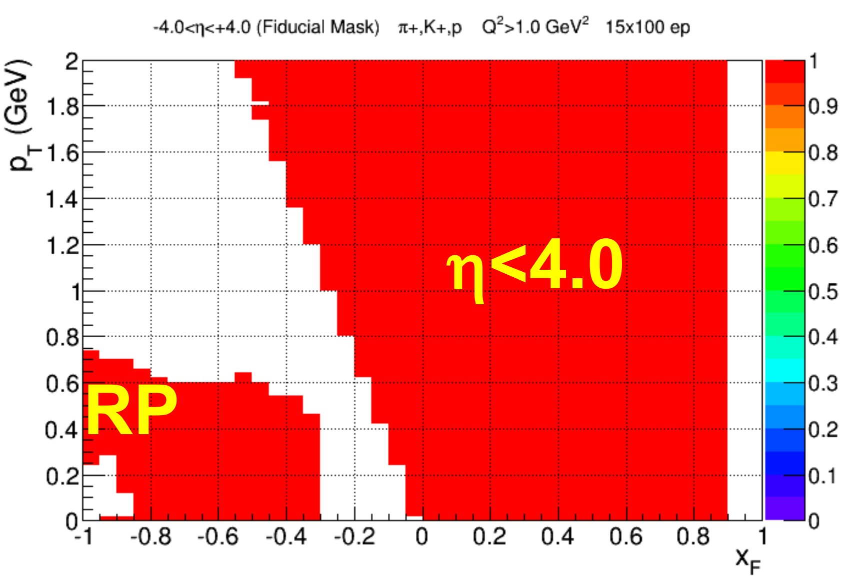
It just causes an inefficiency (up to 40%) for $x_F>0$

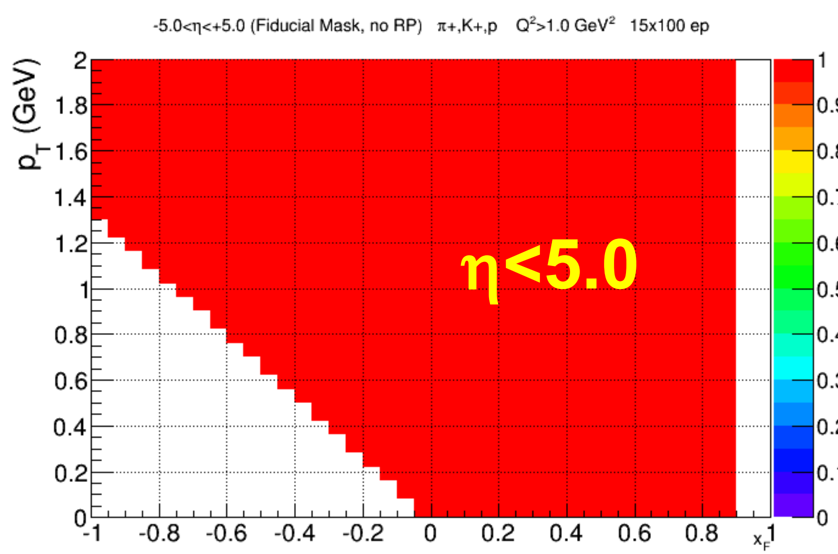
Still "measurable"

Impact of η acceptance (15x100)

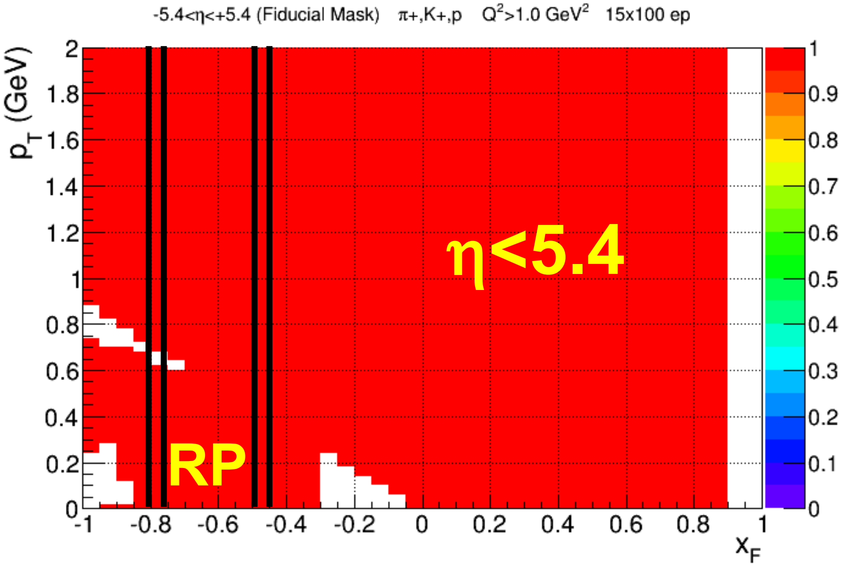


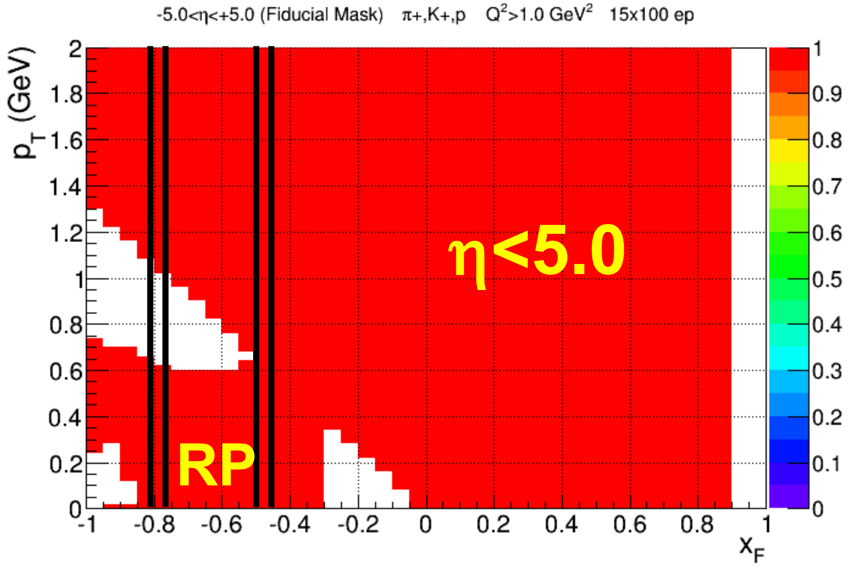






Impact of η acceptance (15x100)

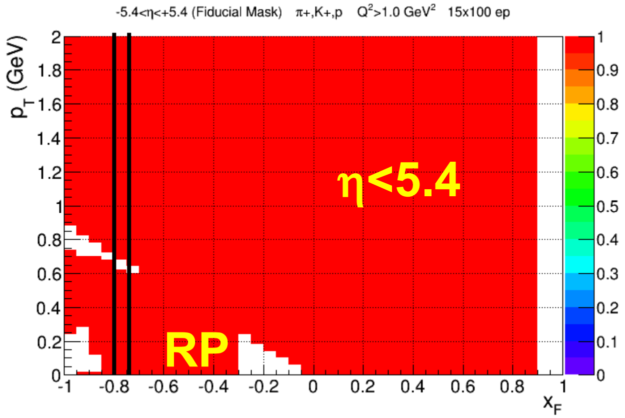


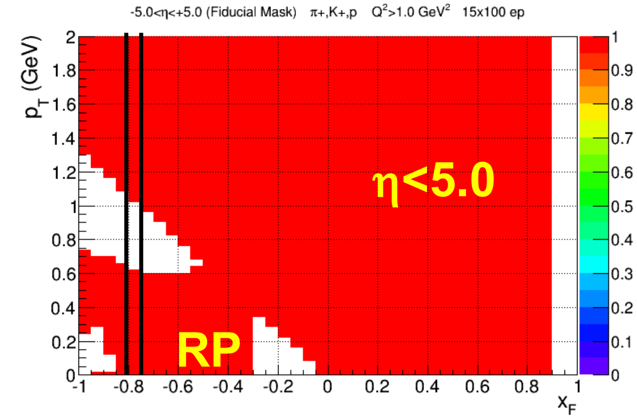


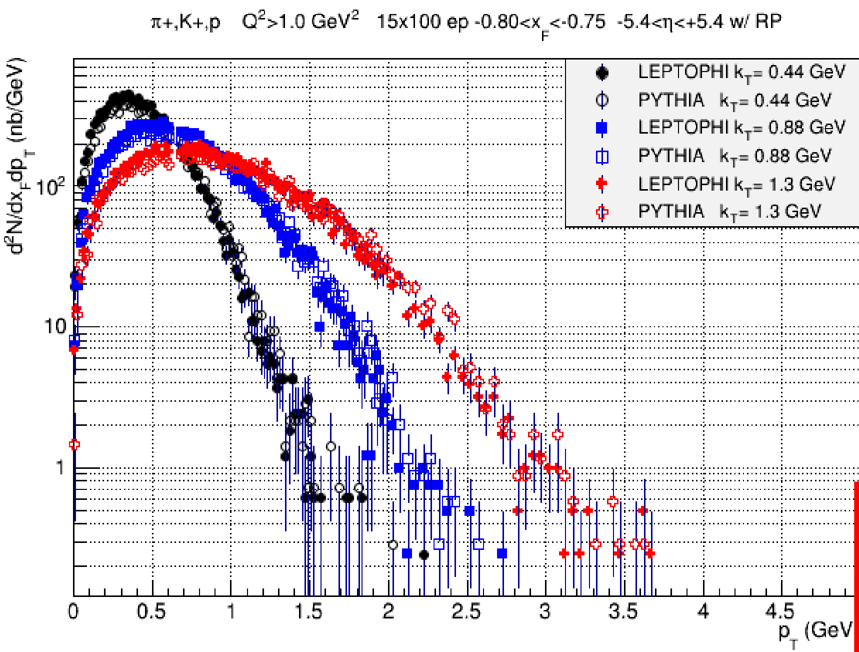
$-0.5<x_F<-0.45$ unaffected by loss of $5.0<\eta<5.4$

$-0.8<x_F<-0.75$ (better bin) is affected.

Impact of η acceptance (15x100)

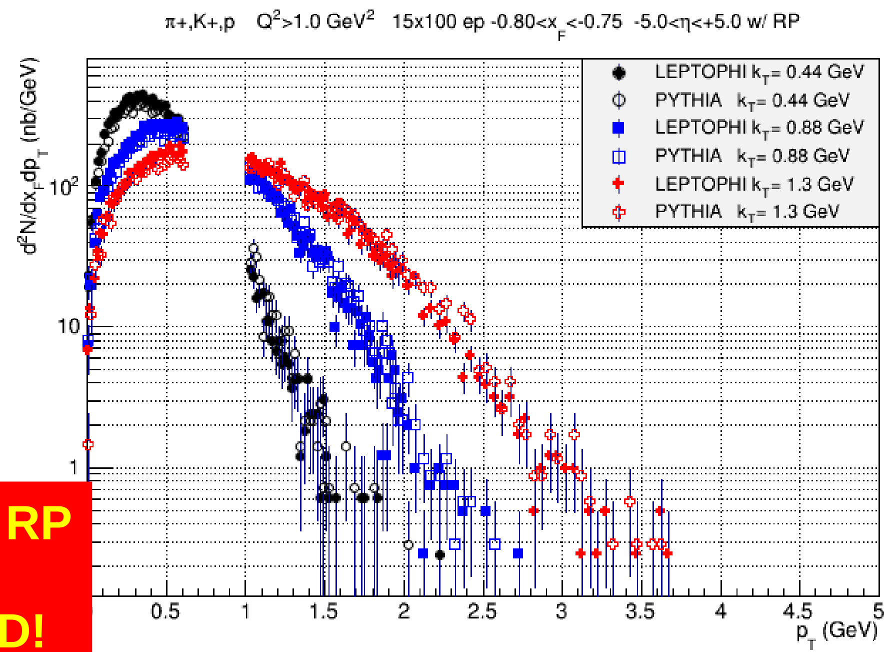






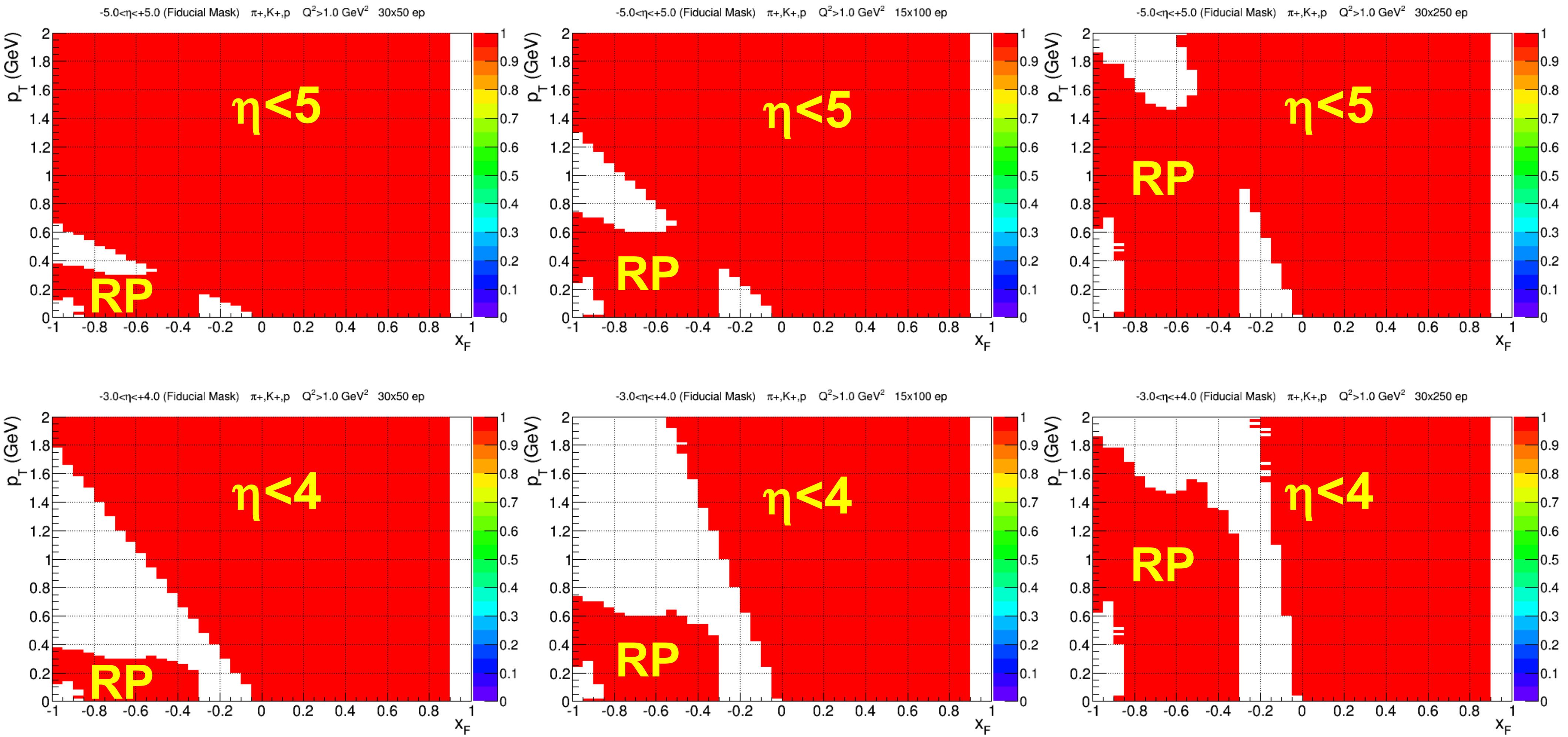
|η|<5.0 + RP

IS GOOD!

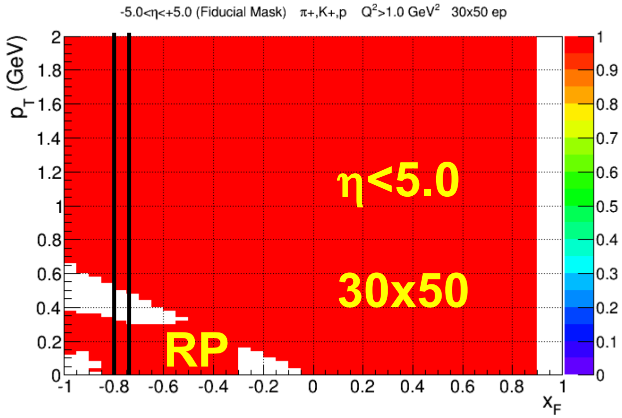


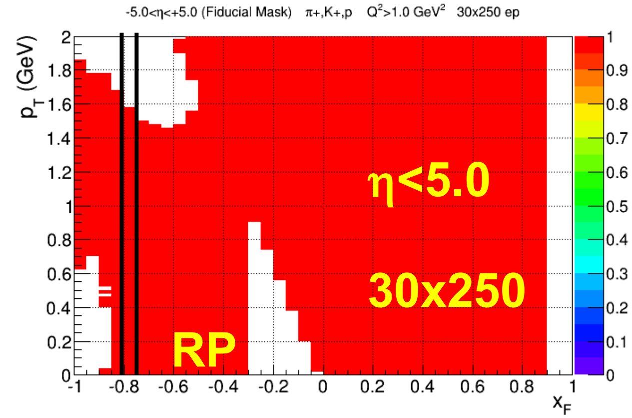
Other Energies

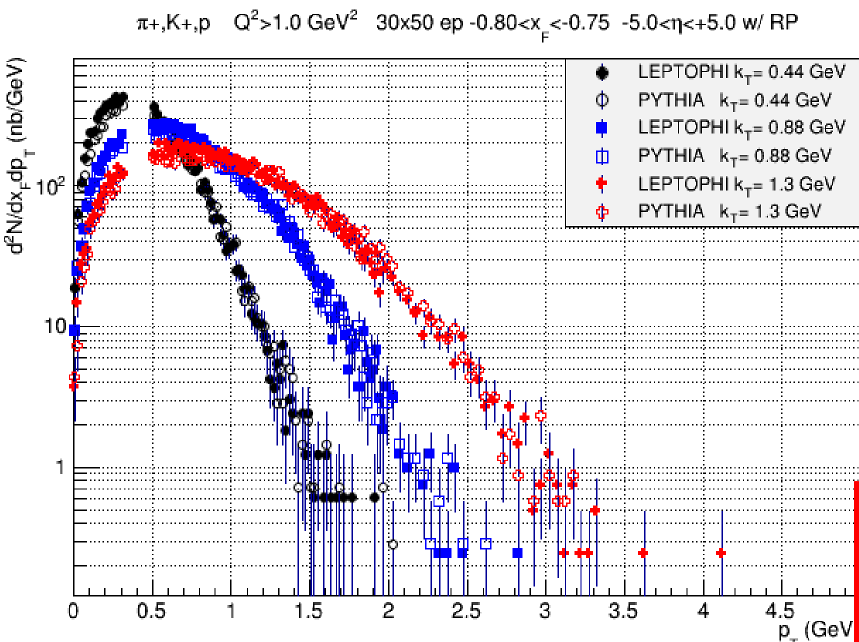
30x50 | 15x100 | 30x250

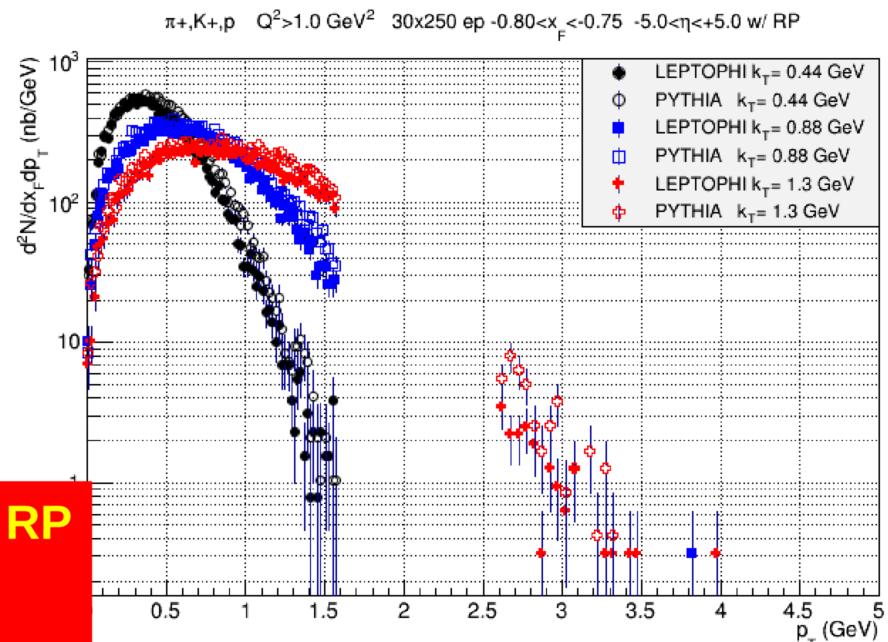


Impact of η acceptance vs. energy









|η|<5.0 + RP

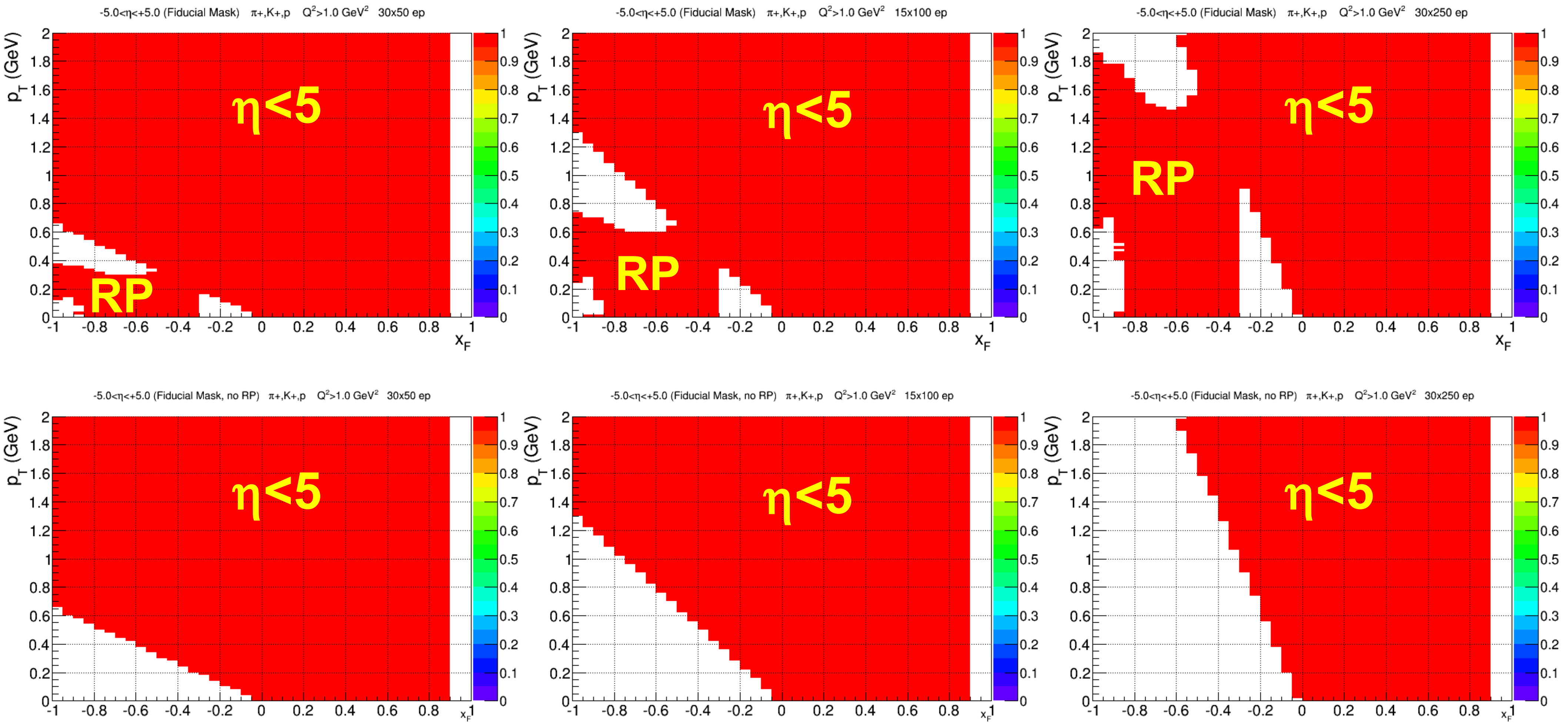
IS OK

Key Points so far

- $|\eta|<5.0$ + RP is good enough
  - Extending to $\eta<5.4$ is not necessary

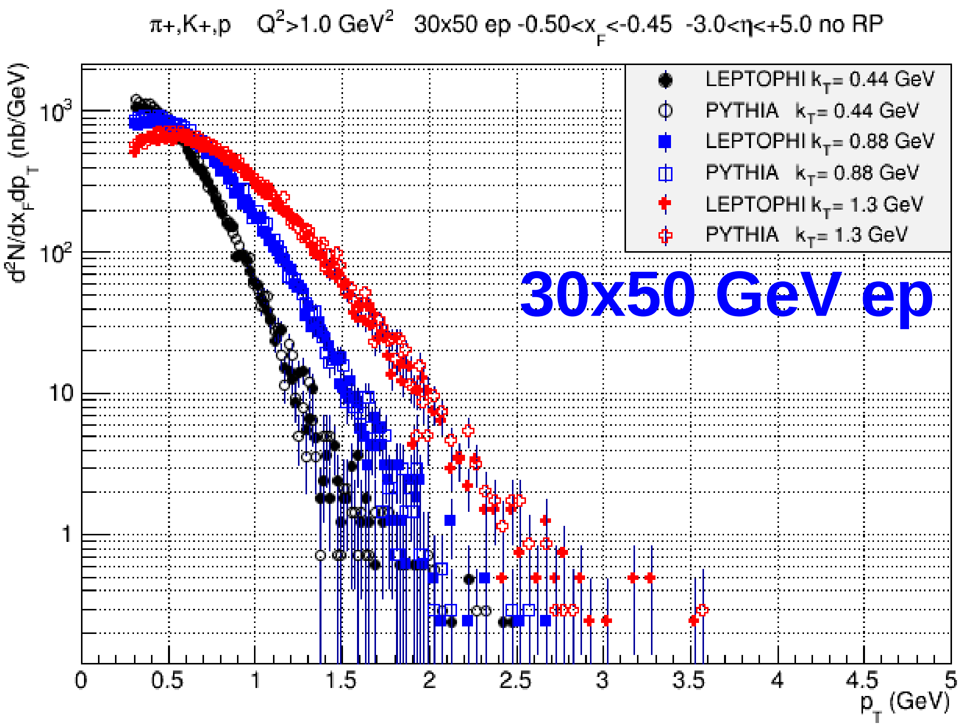
Roman Pot Removal

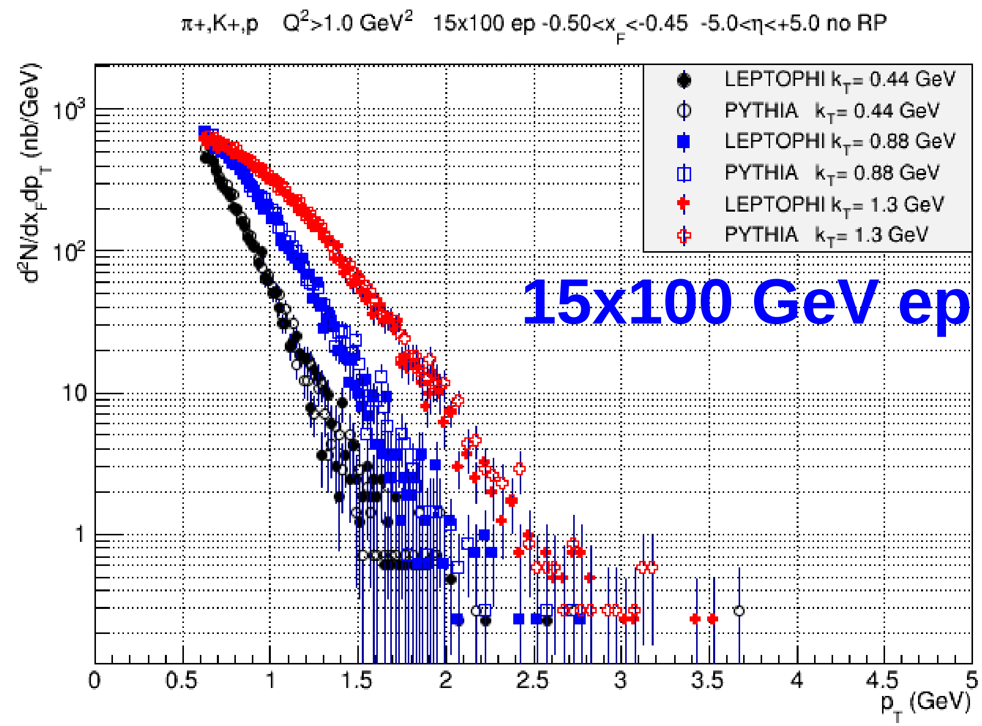
30x50 | 15x100 | 30x250



Effect of Removing Roman Pots (1)

π+,K,p, Q^2>1 GeV^2, -0.50<x_F<-0.45, η<5.0 + NoRP:



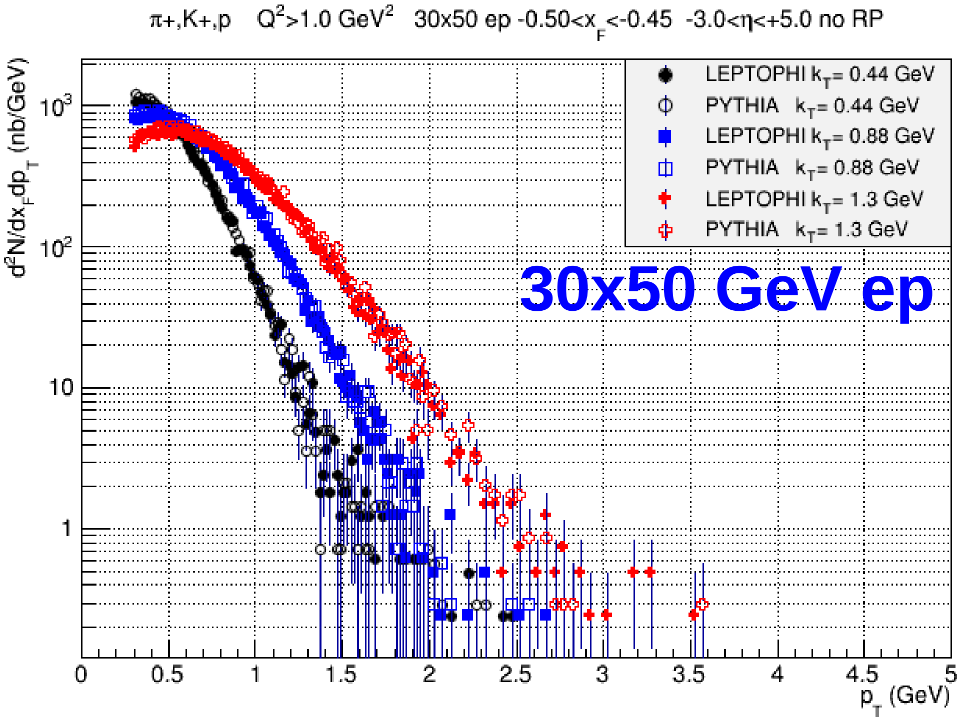


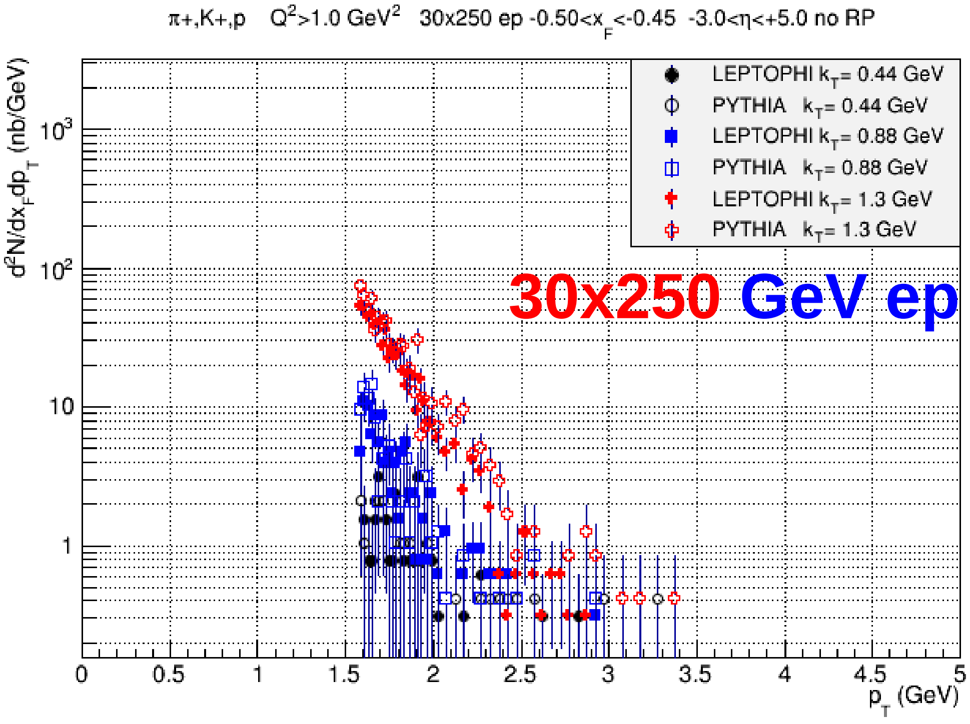
Reasonable measurement

OK, but missing the bulk

Effect of Removing Roman Pots (2)

π+,K,p, Q^2>1 GeV^2, -0.50<x_F<-0.45, η<5.0 + NoRP:



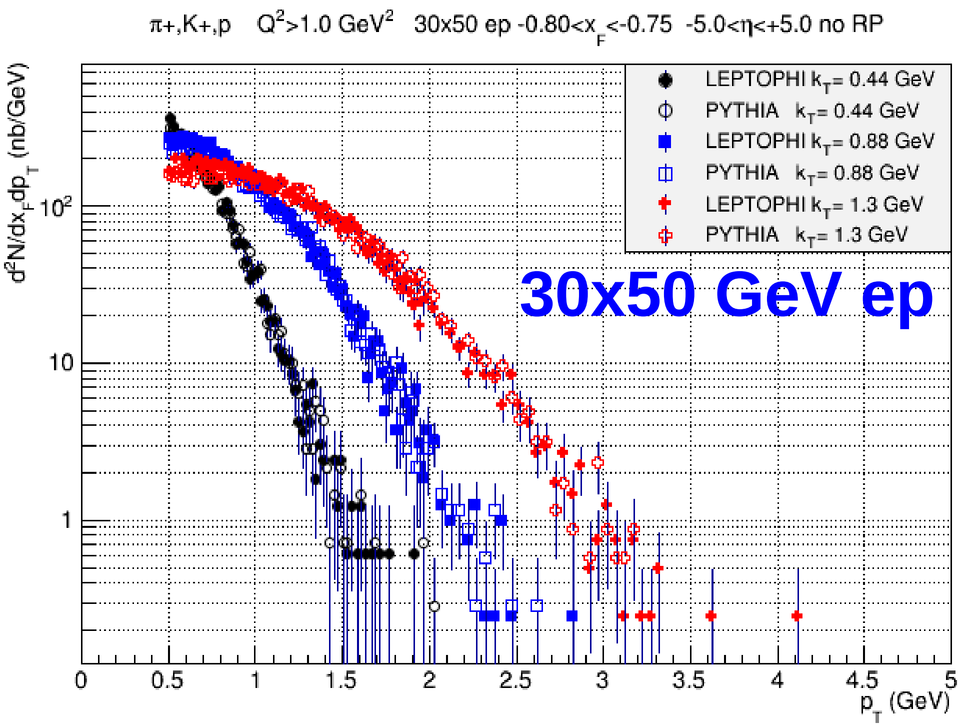


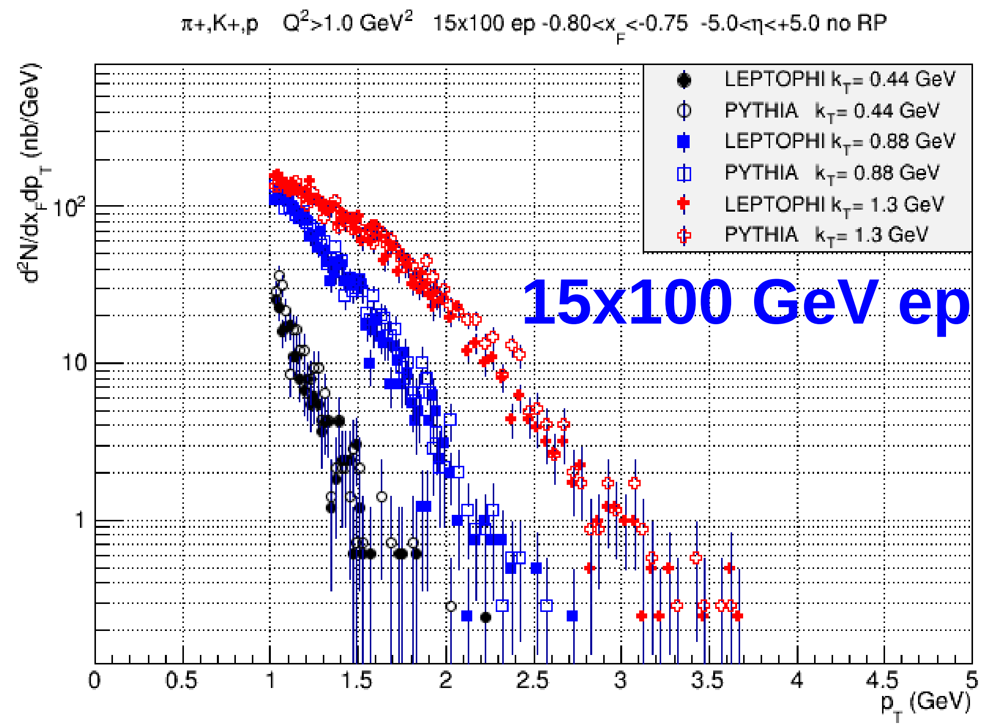
Reasonable measurement

NO!

Effect of Removing Roman Pots (3)

π+,K,p, Q^2>1 GeV^2, -0.80<x_F<-0.75, η<5.0 + NoRP:



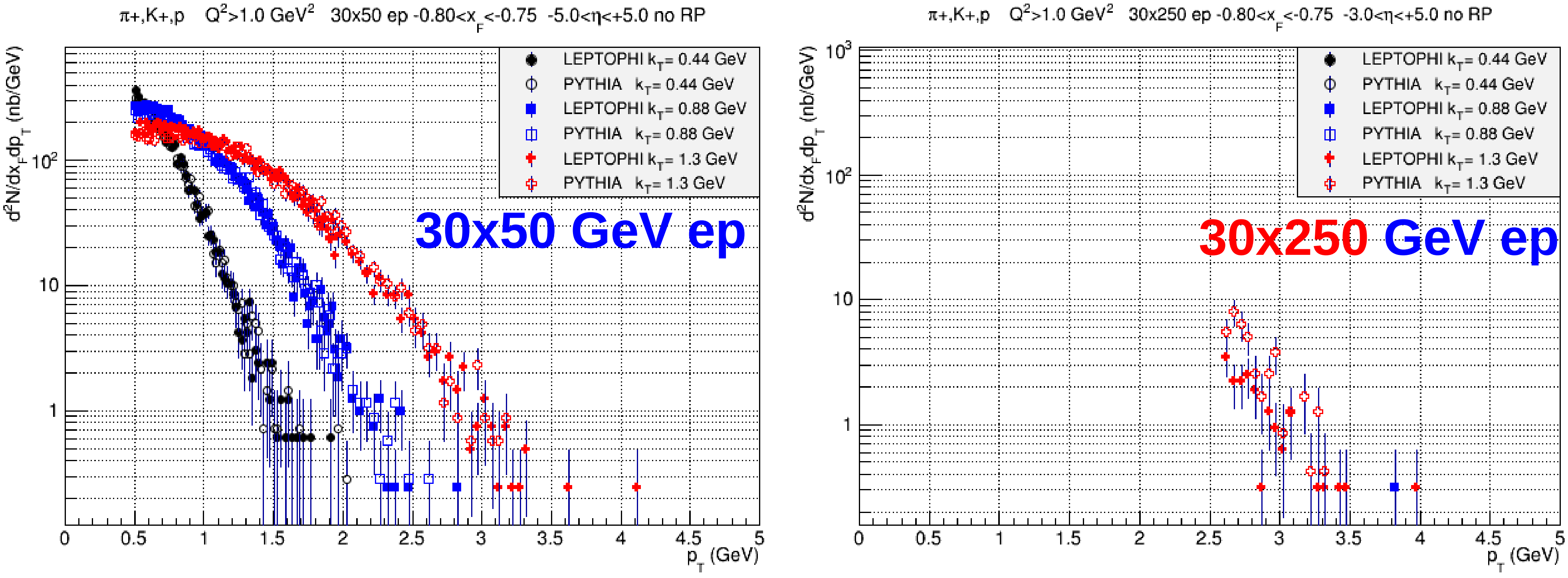


OK, but missing the bulk

WEAK, just the tail

Effect of Removing Roman Pots (4)

π+,K,p, Q^2>1 GeV^2, -0.80<x_F<-0.75, η<5.0 + NoRP:



OK, but missing the bulk

NO!

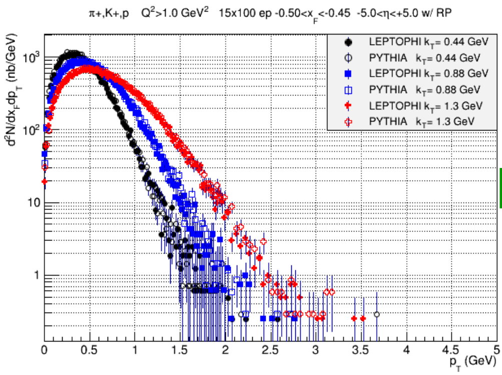
Key Points so far

- $|\eta|<5.0$ + RP is good enough
  - Extending to $\eta<5.4$ is not necessary
- Without Roman Pots:
  Result degraded & we lose energy dependence:
  - p_p = 50 GeV: Still good.
  - p_p = 100 GeV: Useful, but degraded measurement.
  - p_p = 250 GeV: NO

15x100 η acceptance effect

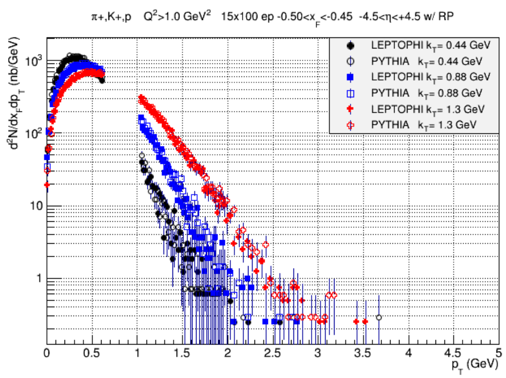
$-0.5<x_F<-0.45$

η<5.0 + RP:



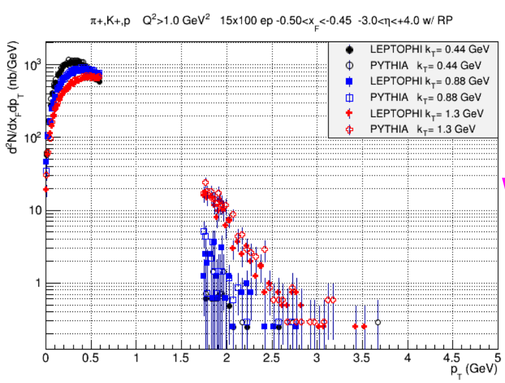
EXCELLENT

η<4.5 + RP:



SOLID

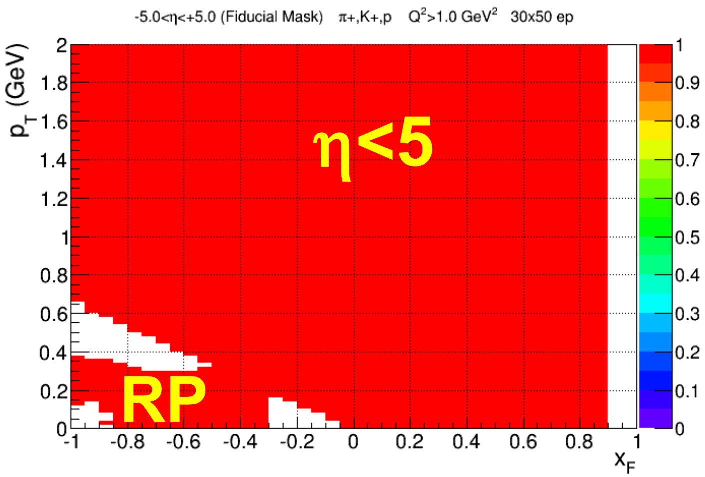
η<4.0 + RP:

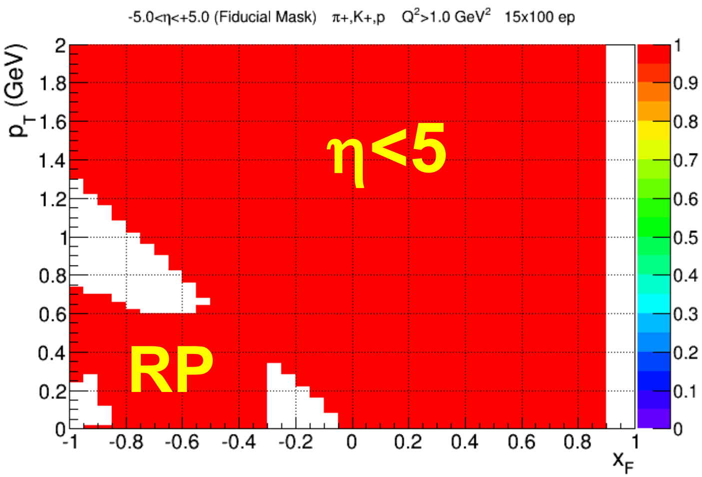


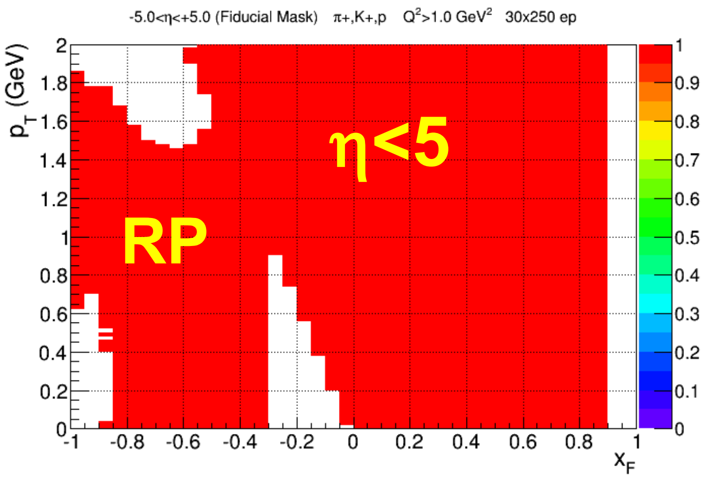
WEAK

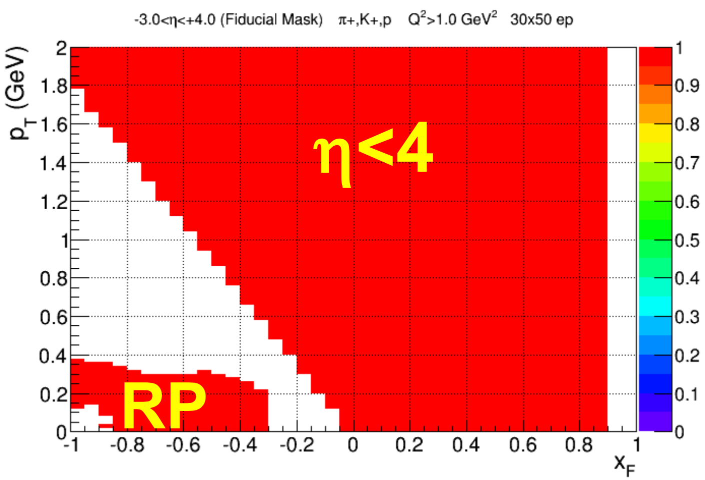
Other Energies

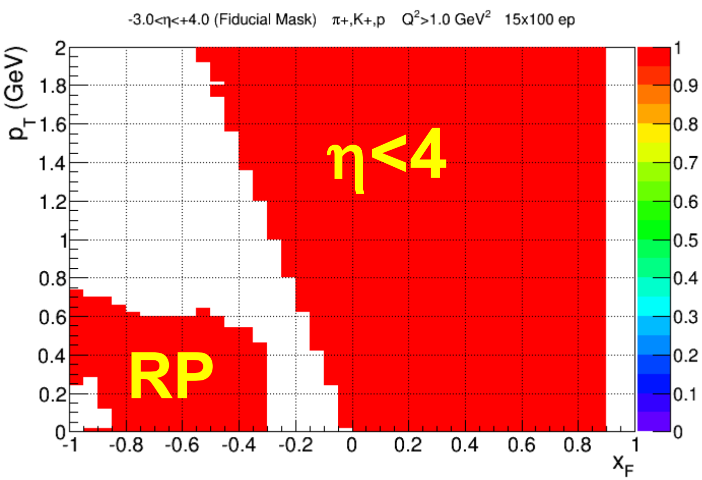
30x50 | 15x100 | 30x250

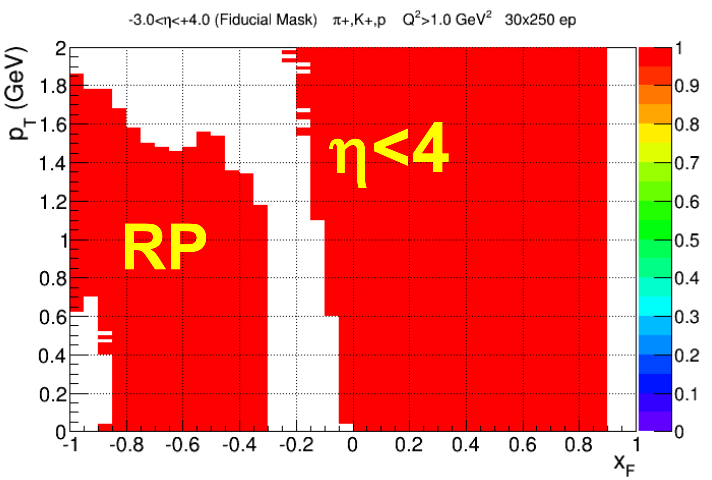








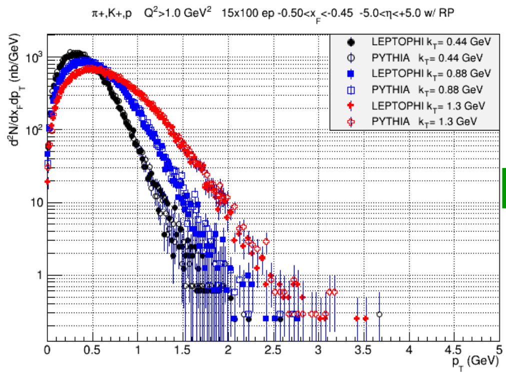




15x100 compared to 30x50

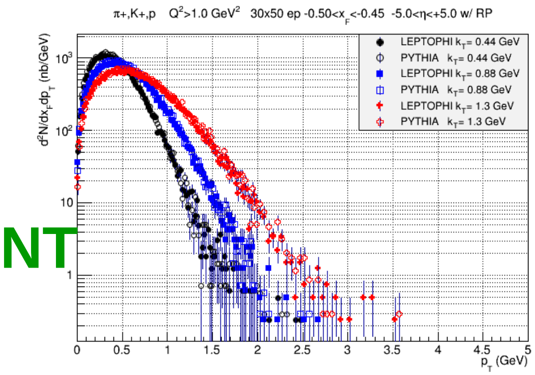
$-0.5<x_F<-0.45$

η<5.0 + RP:

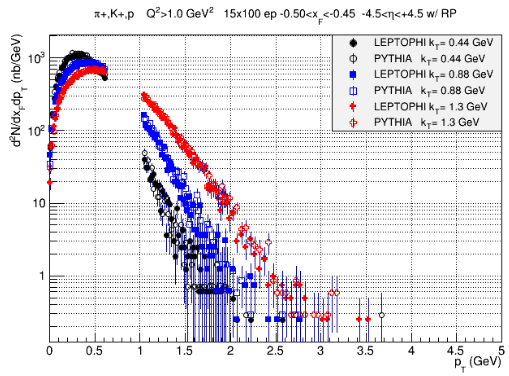


EXCELLENT

EXCELLENT

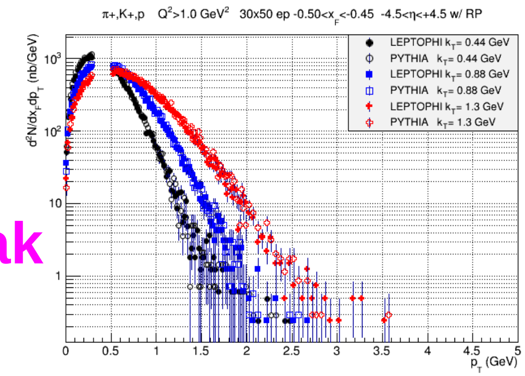


η<4.5 + RP:

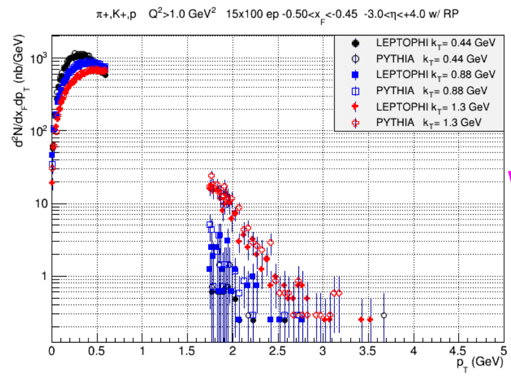


SOLID

OK,
But no peak

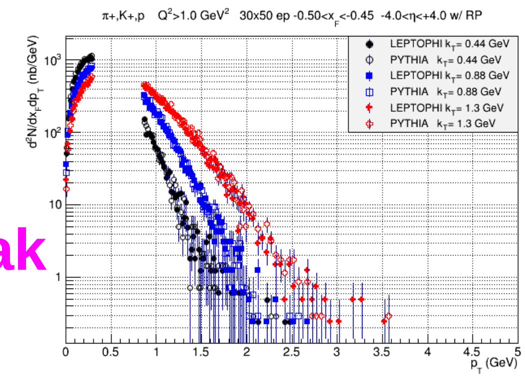


η<4.0 + RP:



WEAK

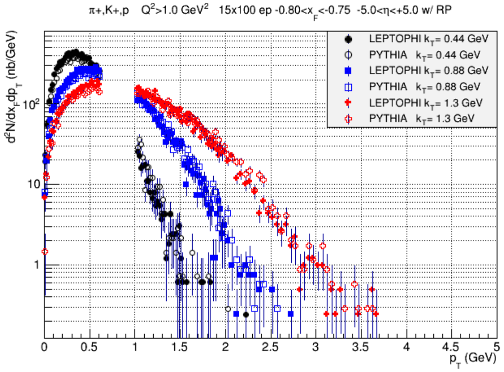
OK,
But no peak



15x100 compared to 30x50

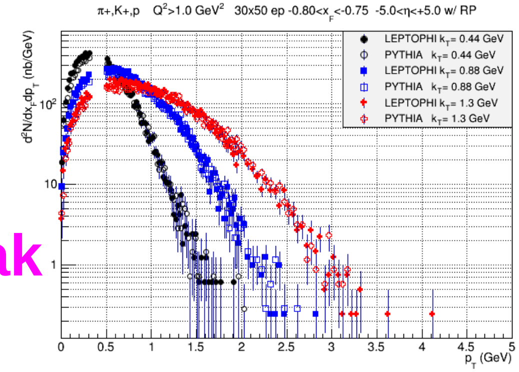
$-0.8<x_F<-0.75$

η<5.0 + RP:

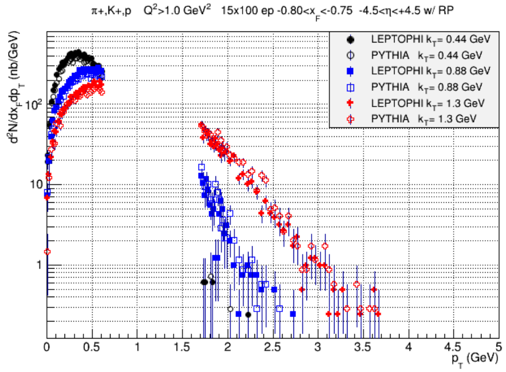


SOLID

OK,
But no peak

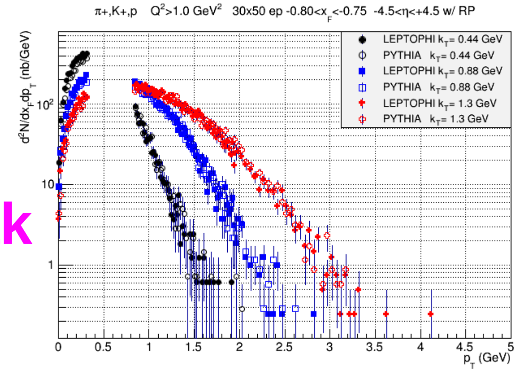


η<4.5 + RP:

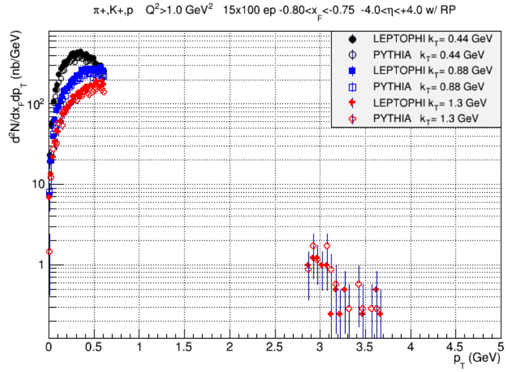


WEAK

OK,
But no peak

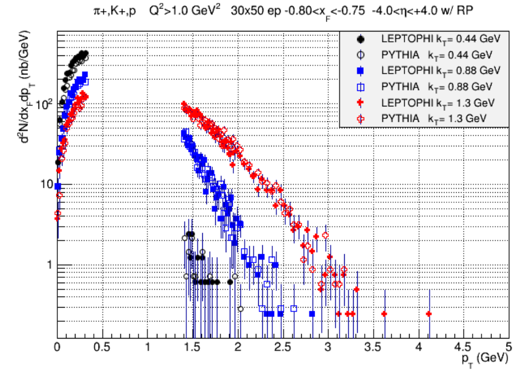


η<4.0 + RP:



NO

WEAK

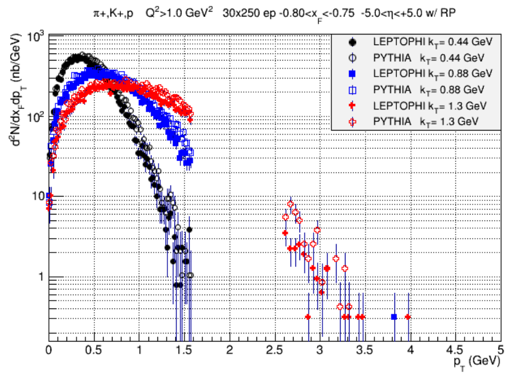


30x250 results

-0.5<x_F<-0.45

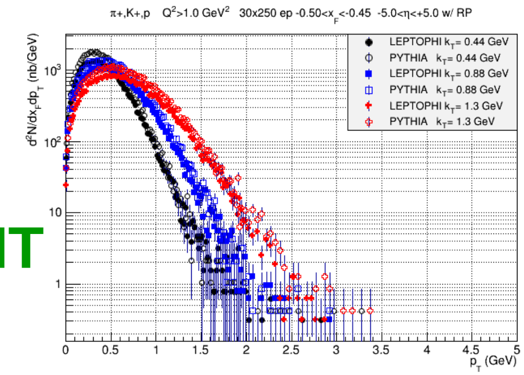
-0.8<x_F<-0.75

η<5.0 + RP:

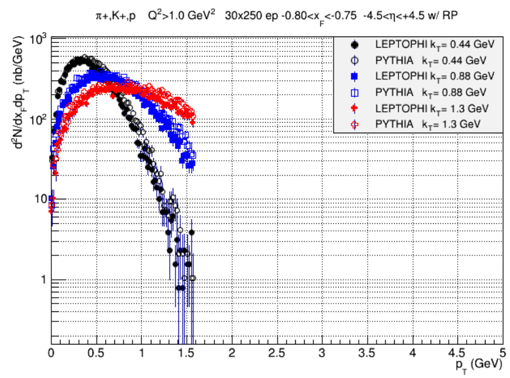


SOLID

EXCELLENT

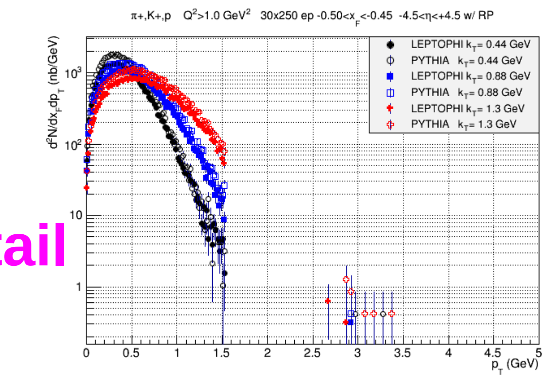


η<4.5 + RP:

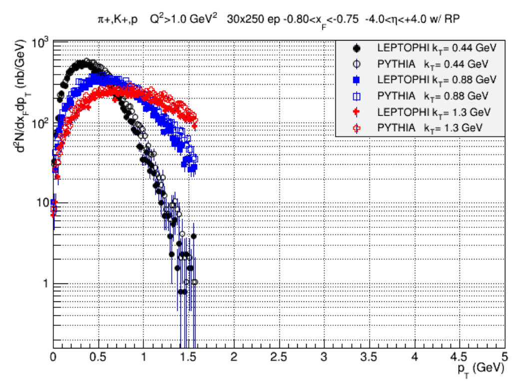


OK,
But no tail

OK,
But no tail

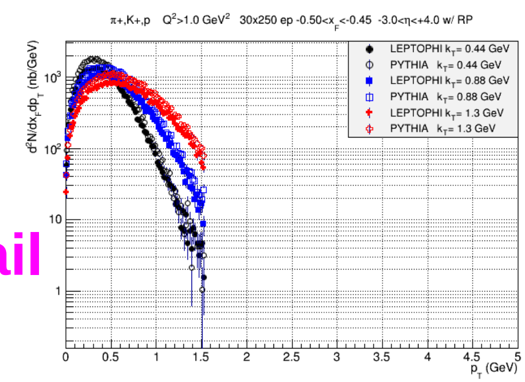


η<4.0 + RP:



OK,
But no tail

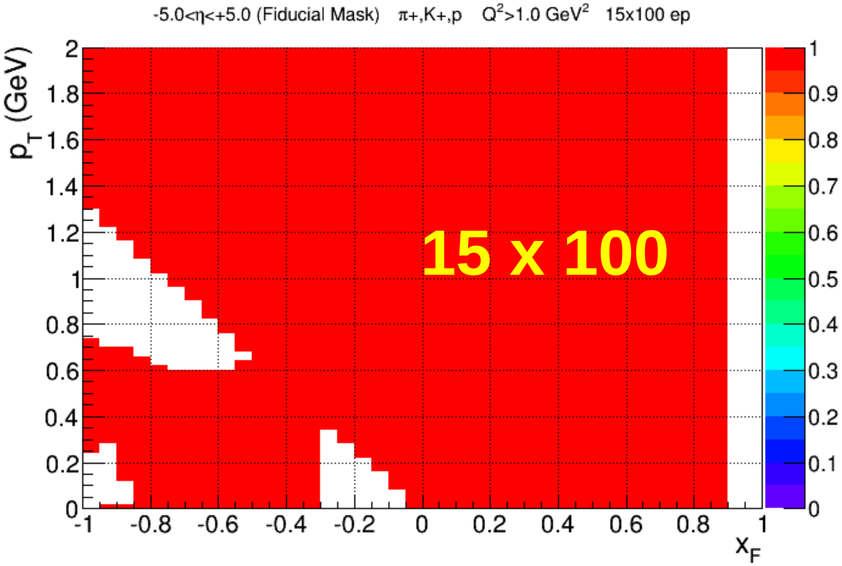
OK,
But no tail

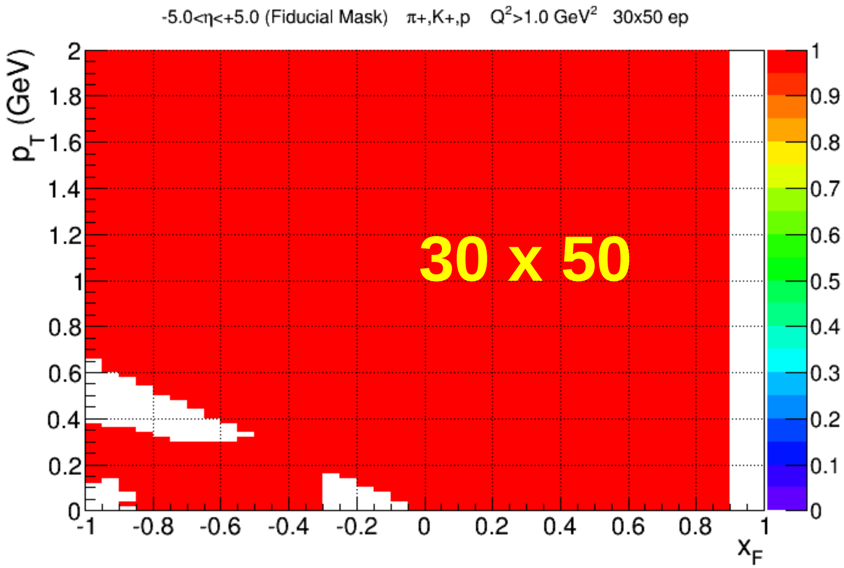


Key Points so far

- $|\eta|<5.0$ + RP is good enough
  - Extending to $\eta<5.4$ is not necessary
- Without Roman Pots:
  Result degraded & we lose energy dependence
- $|\eta|<4.5$ + RP is inferior, but still useful
  - Similiarly with $|\eta|<4.0$ + RP

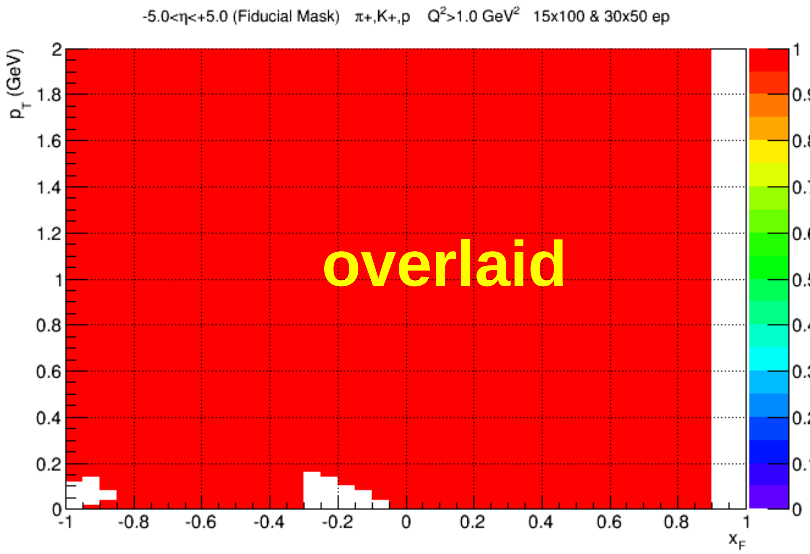
Combining Equivalent Energies





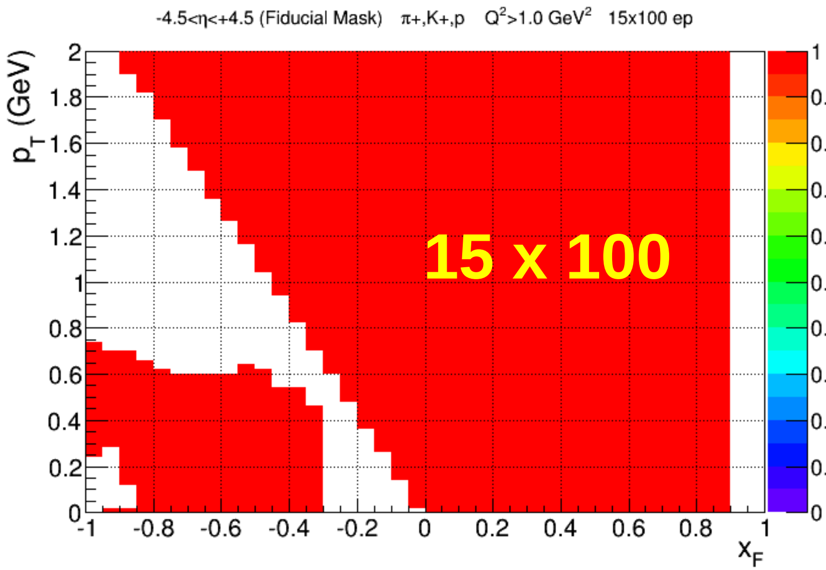
$|\eta|<5$ + RP

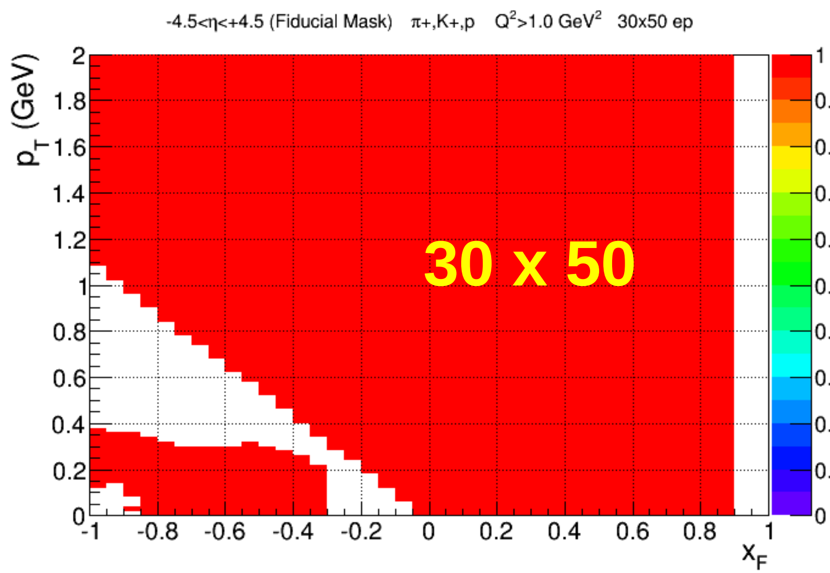
Note: 15x100 = 30x50 (same s!)



REALLY GOOD COVERAGE!
Also great systematic check!

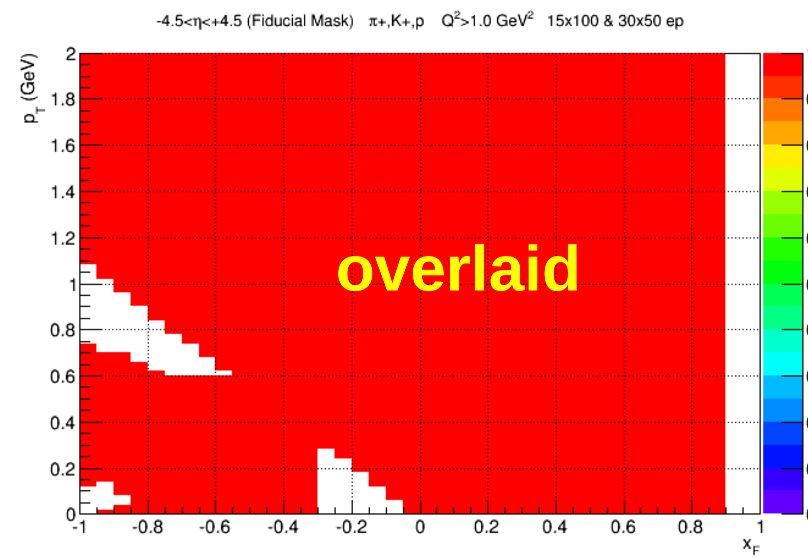
Combining Equivalent Energies





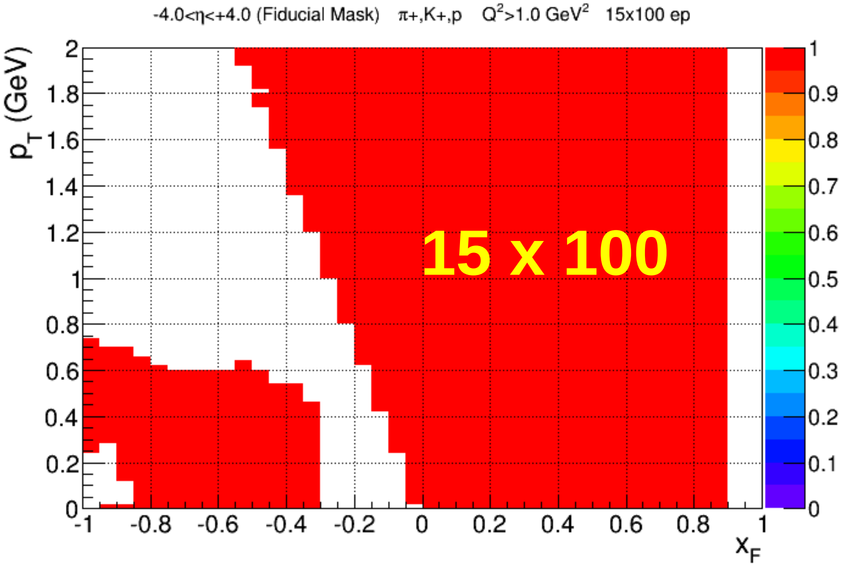
$|\eta|<4.5$ + RP

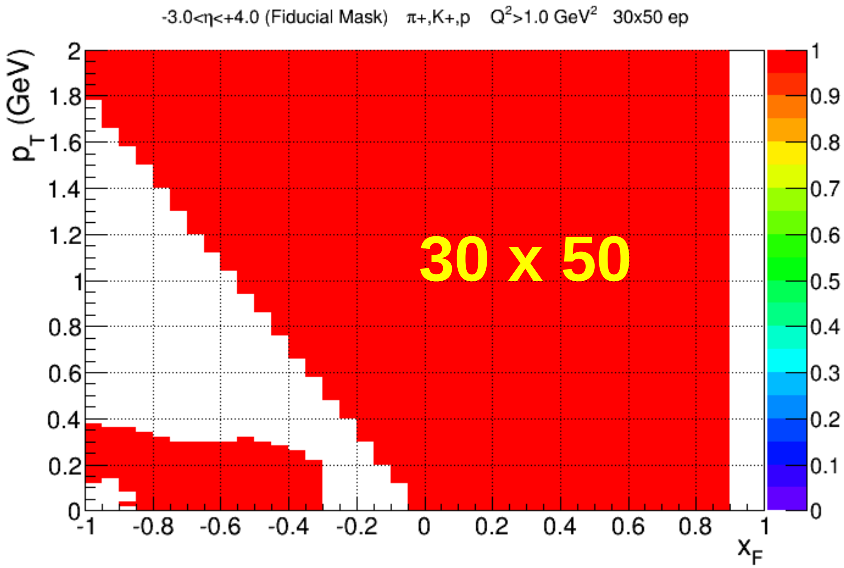
Note: 15x100 = 30x50 (same s!)



Still GOOD COVERAGE

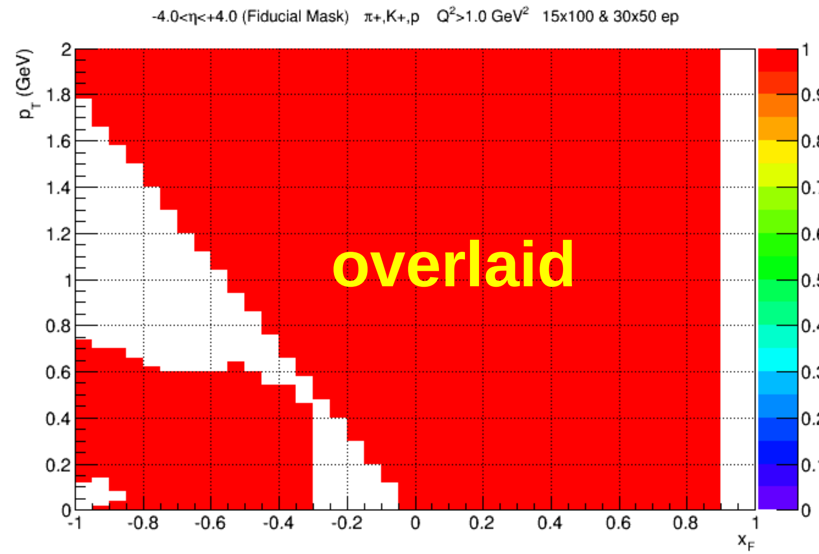
Combining Equivalent Energies





|η|<4 + RP

Note: 15x100 = 30x50 (same s!)



Still OK COVERAGE

Summary

- $|\eta|<5.0$ + RP is good enough
  - Extending to $\eta<5.4$ is not necessary
- Without Roman Pots:
  Result degraded & we lose energy dependence
- $|\eta|<4.5$ + RP is inferior, but still useful
  - Similiarly with $|\eta|<4.0$ + RP
- Combining 15x100 & 30x50 is REALLY GOOD